ENVIRONMENTAL LIFE - CYCLE ASSESSMENT

THE LADDER THAT LIKES THE WALL

LADDER BY XENIA MOSELEY WITH RICHARD AND AB ROGERS

MADE IN AMERICAN RED OAK

THE·WISH·LIST

SUMMARY

While the ladder is composed primarily of American red oak, the overall environmental impact is heavily influenced by the use of other materials, notably the 700 grammes of green leather used for the seat. Substitution of wood for this single component would significantly reduce the environmental burden.

The high environmental impact of leather is due both to energy and chemical inputs associated with cattle farming and the even larger inputs during the manufacturing process. This process involves inputs of chemicals for de-hairing, biocides such as pentachlorophenol to prevent bacterial growth, and compounds of chromium, a heavy metal, for tanning.

According to the designer, choice of the red oak was driven partly by the need to steam bend the timber. The first choice would have been tulipwood for its lightness but that is not appropriate for steam bending. From an environmental impact perspective, choice of oak has marginally increased the carbon footprint because it takes significantly longer to kiln dry than tulipwood.

WOOD RESOURCE

Red oak is the most abundant hardwood in the U.S. forest accounting for 19% of wood volume and is a rapidly expanding resource. U.S. government forest inventory data[1] shows that U.S. red oak is growing 51.9 million m^3 per year while the harvest is 32.4 million m^3 per year. After harvesting, an additional 19.5 million m^3 of red oak accumulate in U.S. forests every year. It takes less than one tenth of a second for the U.S. hardwood logs harvested to manufacture the ladder to be replaced by new growth in the U.S. forest.

CARBON FOOTPRINT

On a cradle to grave basis, the carbon footprint of the ladder is 106 kilograms of CO_2 equivalent. That's roughly equivalent to the carbon emissions of driving 474 miles (764 km) in the average UK car[2].

Carbon emissions during all stages of material extraction and processing, product manufacturing, and transport are 154 kilograms of CO_2 equivalent. The leather alone accounts for 49 kilograms of these emissions while the aluminium for the footings accounts for a further 14 kilograms.

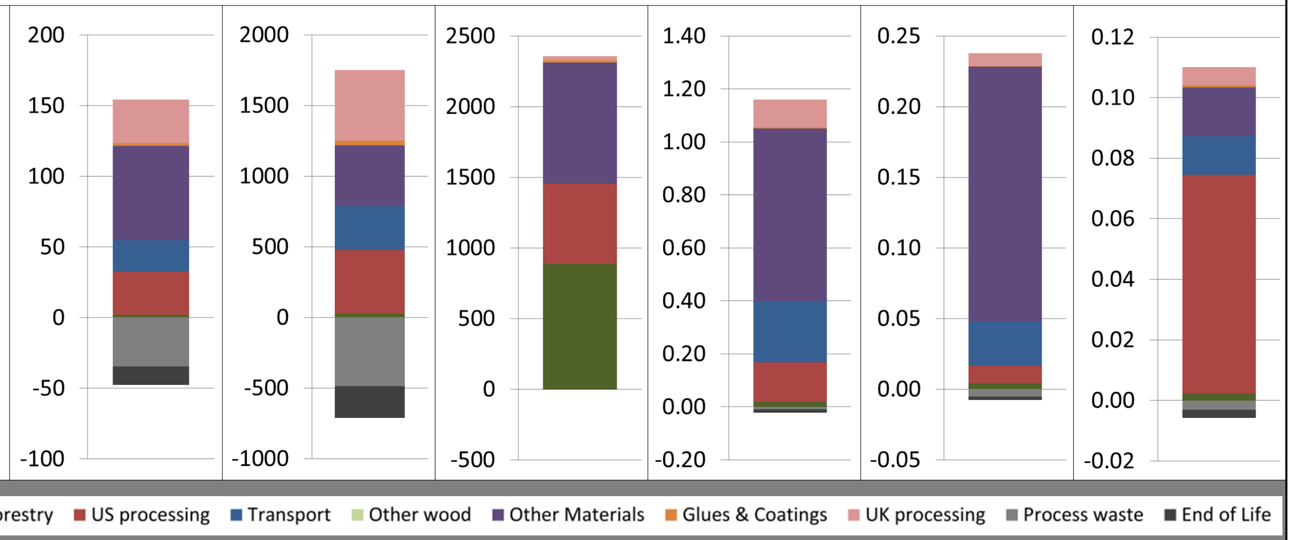
The U.S. hardwood parts of the ladder are nearly carbon neutral. Although 55 kilograms of CO_2 equivalent are emitted during all processes to extract, process and transport the wood, these are offset by 48 kilograms resulting from substitution of fossil fuels through use of wood waste generated primarily during manufacturing.

A large proportion of the wood required to manufacture the ladder did not end up in the finished product. This reduces the long-term carbon storage potential but it also means that there is a significant volume of waste wood diverted to energy production. The overall mass of wood waste arising during manufacture is much greater than the final mass of the product, so the credits from processing waste are greater than those from end of life.

CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE LADDER

Impact category	Global Warming Potential	Primary energy demand (resources)	Primary energy demand (renewable)	Acidification Potential	Eutrophication Potential	Photochemical Ozone Creation Potential
Unit	kg CO2-Equiv.	MJ	MJ	kg SO2-Equiv.	kg Phosphate-Equiv.	kg Ethene-Equiv.
Total	106	1039	2354	1.14	0.23	0.10

Data by process steps



OTHER IMPACTS

The total eutrophication potential of the ladder is 0.23 kg of phosphate equivalent, about the same as caused each year by conventional farming of 104 square meters of land for wheat in the UK[3].

The leather is the largest contributor to eutrophication potential, alone accounting for 0.18 kg of phosphate equivalent. Much of the rest is due to nitrate emissions during burning of fuels for transport and processing of materials. Hardly any eutrophication potential is linked to growth of U.S. hardwoods which thrive under natural conditions and very rarely require fertilisers.

The ladder's acidification potential is 1.14 kg of SO_2 equivalent, nearly two thirds of which is due to the leather. Also significant are emissions during shipping of hardwoods from the U.S to the UK and results from the relatively high sulphur content of marine fuels. The other significant contributor to acidification potential is the use of grid electricity during processing of hardwood in the United States, mainly to power the fans in the kilns.

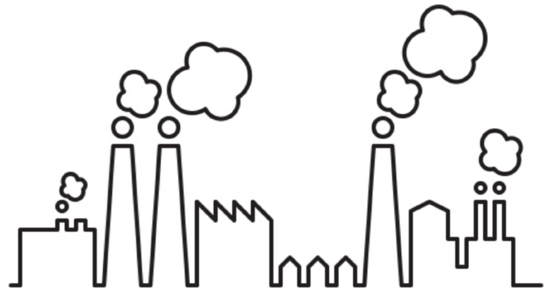
Around 70% of the ladder's photo-chemical ozone creation potential (POCP) of 0.10 kg of Ethene equivalent is due to kiln drying of U.S. hardwood. It results from the presence of terpenes, naturally occurring VOCs, in wood resin. Although terpenes are released naturally as trees grow, processes in which wood is heated lead to more significant emissions. Around 15% of the POCP of the ladder is associated with supply of the small quantity of leather and aluminium.

The large input of renewable energy – 2354 megajoules – is due partly to the leather manufacturing process and partly to the high proportion of thermal energy derived from burning of wood waste during kiln drying. At least 90% of all thermal energy used for kiln drying in the U.S. hardwood sector is derived from biomass. The high proportion of renewable energy attributed to the forestry stage is a peculiarity of life cycle inventory rules for wood products and has nothing to do with the energy used during forestry operations. It is the solar energy that is absorbed by the tree during growth and converted into chemical energy within the wood itself. In other words it is the energy that would have been released if the wood were burnt immediately after harvest.

MATERIALS USED FOR THE LADDER

Wood materials	Use	Volume (m^3)
American red oak sawn 2.5" thick	Main structure	0.07368
Other materials	**Use**	**Weight (g)**
Stainless steel	Footings	334g
Steel studding	Footings	943g
Cast aluminium	Footings	1384g
Green leather	Seat	700g
Pink stain	Finishing	50ml
Osmo oil	Finishing	250ml
Black rubber	Footings	264g

ENVIRONMENTAL IMPACT CATEGORIES

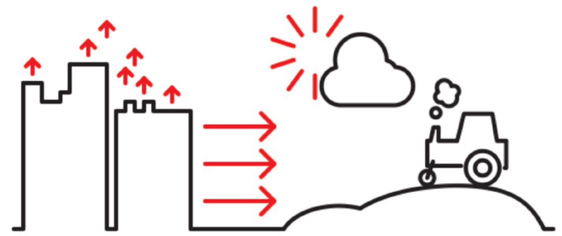


1 PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

This is a measure of the total demand of primary energy that comes from non-renewable resources, such as oil and natural gas. Measured in gigajoules (GJ), the primary energy demand takes into account the conversion efficiencies from the primary energy to, for example, electricity. The generation of carbon dioxide from the production of energy is one of the major causes of global warming.

2 PRIMARY ENERGY DEMAND (RENEWABLE RESOURCES)

Like the primary energy demand from non-renewable resources, this is a measure of the total amount of primary energy, but in this case, derived from renewable sources such as hydropower and wind energy. Again, it takes conversion efficiencies into account where appropriate. Total primary energy demand can be measured by adding the figures for energy from non-renewable and renewable resources

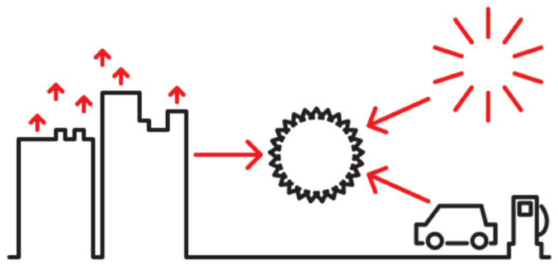


3 GLOBAL WARMING POTENTIAL (GWP)

Global warming is usually regarded as one of the most significant environmental issues. Global Warming Potential, measured in kg CO2 equivalent, is also a good marker for other environmental impacts. It is calculated from the volumes of greenhouse gases, such as carbon dioxide and methane, emitted during a process.

4 ACIDIFICATION POTENTIAL (AP)

This is a measure of the emissions that cause acidifying effects to the environment, which can cause imbalances and the death of species. Emissions of sulphur dioxide and nitrous oxide result in acid rain which can fall some way from the place where the emissions occur. Acidification potential is measured in kg of sulphur dioxide equivalent.



5 EUTROPHICATION POTENTIAL (EP)

Eutrophication is the process by which water receives an excessive amount of nutrients, particularly phosphates and nitrates. These nutrients, which typically come from run-off from fertilisers, lead to algal blooms which, in turn, deprive the water of oxygen and lead to imbalances and deaths in the aquatic populations. Eutrophication is measured in terms of kg of phosphate equivalent, and kg of nitrogen equivalent.

6 PHOTOCHEMICAL OZONE CREATION POTENTIAL (POCP)

This is a measure of emissions or precursors that contribute to low-level smog. It is measured in kg of ethene equivalent. Ozone layer depletion potential (ODP) is also part of the i-report but is not included in the charts because the effect is negligible. There may seem to be a contradiction between these two impacts but, put simply, high-level ozone is good and should be protected, whereas ozone at ground level is a pollutant.

NOTES

1. Figures based on 2011/2012 data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program at http://www.fia.fs.fed.us/
2. Assumes average CO_2 emissions of 139g/km for all the UK's major new cars calculated by Carpages at http://www.carpages.co.uk/co2/
3. Based on Williams *et al* 2010 at Cranfield Natural Resources Management Institute who for 1 tonne of bread wheat from conventional farming in the UK assessed Eutrophication Potential of 3.1 kg of phosphate equivalent and average occupation of 0.14 hectares of Grade 3a agricultural land.

ENVIRONMENTAL LIFE-CYCLE ASSESSMENT

Environmental life-cycle 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 (see page 3). LCA may also provide qualitative assessment of other environmental impacts such as on biodiversity and land-use that are less easy to quantify.

The LCA of The Wish List builds on a two-year study, commissioned by AHEC and undertaken by PE International, to assess environmental impacts associated with delivery of US hardwood material into world markets[a]. This involved a wide-ranging independent assessment of hardwood forestry practices and a survey of the hundreds of US companies engaged in the processing and export of hardwood products.

Life cycle inventory data from the LCA of US hardwoods was combined with data gathered during product manufacture at Benchmark in the UK. It was also combined with PE's existing life-cycle inventory database which covers an expanding range of non-wood materials and product groups.

Using PE's Gabi software for LCA, the data was analysed to quantify environmental impacts.

To model the cradle-to-grave impact of the ladder, the following assumptions are made about waste disposal during manufacture at Benchmark and at the end of the product's life.

- 80% of hardwood waste is used as a fuel for biomass boilers, substituting for light fuel oil.
- The remaining 20% of hardwood waste is reused for other products (no benefits have been modelled for this option).
- Other parts (including glues, coatings, fittings, etc.) are incinerated with electricity and thermal energy recovery using appropriate datasets.

These assumptions are based on information gathered from Benchmark about its standard procedures for use of waste and from secondary sources about waste-disposal practices in the UK.

a. The PE LCA study of US sawn hardwood is available at http://www.americanhardwood.org/fileadmin/docs/sustainability/Final_LCA_Lumber_report.pdf