ENVIRONMENTAL LIFE - CYCLE ASSESSMENT

ROOM

DOOR, SHELF AND HOOKS BY STUDIO ARETI WITH JOHN PAWSON

MADE IN AMERICAN WHITE OAK AND BLACK WALNUT

THE · WISH · LIST

SUMMARY

The wood content of the door and the shelf is the major determinant of environmental impact, both positive and negative. This is a consequence of the relative simplicity of the designs which allows the wood to speak for itself and avoids the need for elaborate processing and finishing. The carbon footprint of the all the pieces is very low, in the case of the shelf better than carbon-neutral on a cradle to grave basis. Very few non-wood materials are used and the carbon emissions from supply of wood are offset by energy recovery from wood waste which substitutes for fossil fuels.

Despite their small dimensions, the LCA of the hooks provides interesting insights into the environmental impacts of wood products. Of all the products in The Wish List, the hooks had the lowest wood content. As a result much impact is attributable to use of electrical energy during fabrication at Benchmark. There's also little wood waste to use for energy to offset the carbon footprint. As a result the hooks, unlike the shelf, are not quite carbon neutral. However this could probably be remedied through minor changes to material use and the processing steps. Also, given the small volume of wood involved, the hooks would normally be manufactured from other product offcuts, thereby increasing overall efficiency and reducing the total environmental burden of the furniture operation.

WOOD RESOURCE

The door is composed of American white oak, one of the most abundant hardwoods in the U.S. forest accounting for 15% of wood volume. U.S. government forest inventory data[1] shows that U.S. white oak is growing 36 million m^3 per year while the harvest is 19.3 million m^3 per year. After harvesting, an additional 16.7 million m^3 of white oak accumulates in U.S. forests every year. It takes around a quarter of a second for new growth in the U.S. forest to replace the hardwood for the door.

The shelf and the hooks are made of walnut which is a large and expanding resource. Every year, 2.4 million m^3 of walnut accumulate in U.S. forests even after harvesting. It only takes around two seconds for new growth in the U.S. forest to replace the walnut logs harvested to manufacture the shelf and hooks.

CARBON FOOTPRINT

On a cradle to grave basis, the carbon footprint of the door is 28 kilograms of CO_2 equivalent. That's roughly equivalent to the carbon emissions of driving 127 miles (205km) in the average UK car[2].

Carbon emissions during all stages of material extraction and processing, manufacturing, and transport are 155 kilograms

of CO_2 equivalent. Of total carbon emissions, 115 kilograms of CO_2 equivalent are associated with processing and supply of American white oak to the UK. However these are offset by 127 kilograms of avoided carbon emissions resulting from substitution of fossil fuels through reuse of wood waste. Efficient utilisation of material means there is relatively little manufacturing waste and a large share of the carbon in the wood supplied to Benchmark ends up stored in the door. The credits received for energy production from wood waste during manufacturing are about equivalent to those received from final disposal at End of Life.

Only a small proportion of emissions – 19 kilograms of CO_2 equivalent - are due to the electrical energy used at Benchmark to manufacture the door. The carbon footprint of glues, coatings, and non-wood materials is negligible.

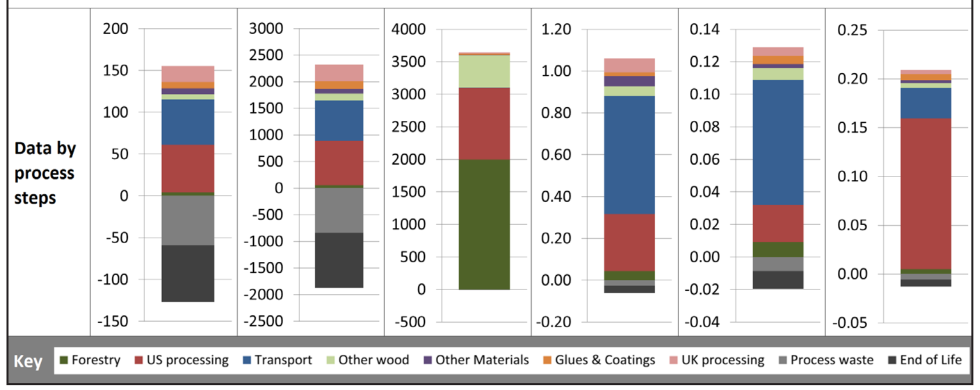
The shelf is carbon neutral when assessed on a full life cycle basis. Total emissions during all processes of material extraction and processing, manufacturing, and transport are 59 kilograms of CO_2 equivalent. These emissions are more than offset by 63 kilograms of avoided carbon emissions resulting from substitution of fossil fuels through reuse of wood waste. Around 50% of wood waste is derived from the manufacturing process and 50% from disposal of the shelves at end of life.

OTHER IMPACTS

The total eutrophication potential of the door is 0.11 kg of phosphate equivalent, about the same as caused each year by conventional farming of 50 square meters of land for wheat in the UK[3]. Nearly all eutrophication potential is due to nitrate emissions during burning of fuels for transport and

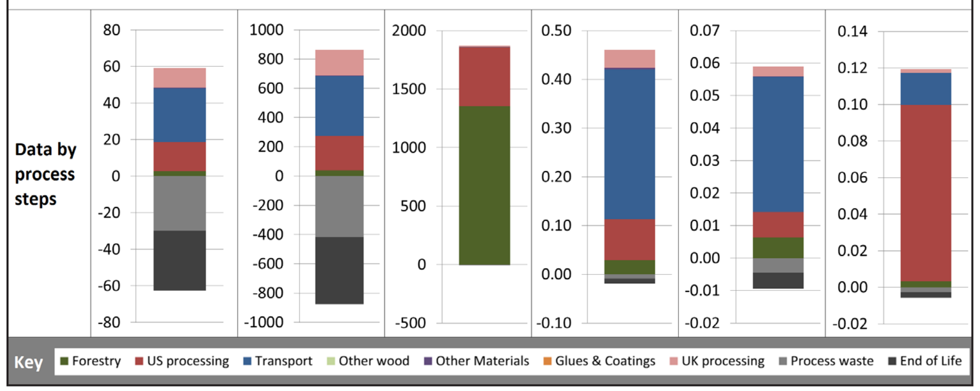
CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE DOOR

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	28	450	3632	1.00	0.11	0.20



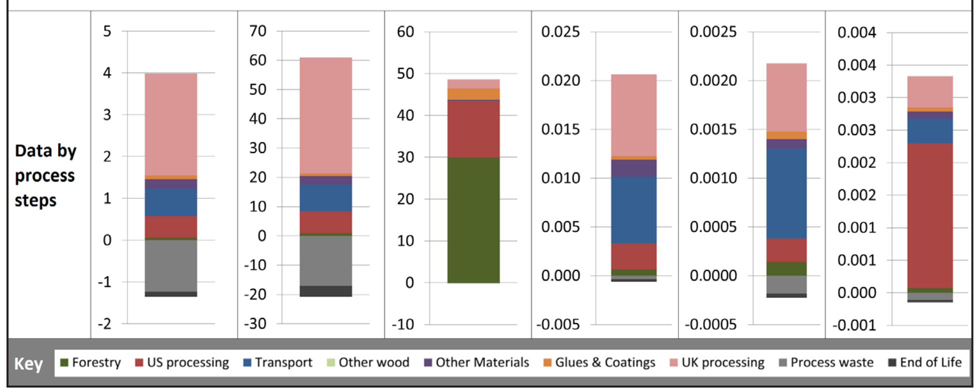
CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE SHELF

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	-4	-12	1869	0.44	0.05	0.11



CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE HOOKS

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	3	40	49	0.020	0.002	0.003



MATERIALS USED FOR THE DOOR

Wood materials	Use	Volume (m^3)
White oak sawn 2"	Structure	0.1125
White oak veneer	Face	0.0515
Birch plywood	Structure	0.041135
Other materials	**Use**	**Weight (kg)**
Glues	Fixings	1875
Screws	Fixings	32g
Veneer tape	Edging	1/2 a roll
Standard latch lock	Functional element	2000g
Raw osmo oil	Finish	200ml

MATERIALS USED FOR THE SHELF

Materials	Use	Quantity
American walnut sawn 32mm	Structure	0.113 m3
Screws	Fixings	6g
Key hole plates	Fixings	32g
Beeswax	Finish	50ml

MATERIALS USED FOR THE HOOKS

Materials	Use	Quantity
American walnut sawn 2"	Structure	0.0025 m3
Epoxy resin glue	Fixings	6g
Screws	Fixings	32g
Clear osmo oil	Finish	50ml

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.

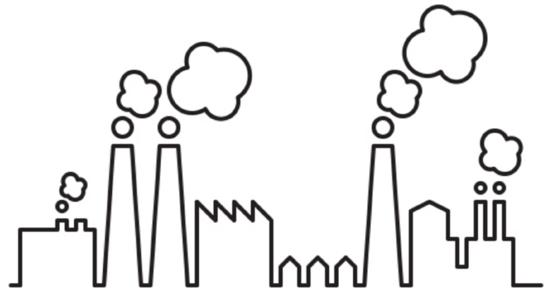
Given the low impact across other categories, the door's acidification potential of 1 kg of SO_2 equivalent is relatively more significant. Much acidification potential results from emissions during shipping of hardwoods from the U.S. to the UK and is due to the relatively high sulphur content of marine fuels. The other main 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.

The door's POCP of 0.20 kg of Ethene equivalent is also significant. U.S. hardwood processing is the main contributor to POCP due to the presence of terpenes, naturally occurring VOCs, in wood resin. Although terpenes are released naturally as trees grow, processes in which wood is heated (such as kiln drying) lead to more significant emissions.

The large input of renewable energy – 3632 megajoules – to manufacture the door is due partly to the high proportion of thermal energy derived from burning of wood waste during the hardwood kiln drying process. 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 the solar energy absorbed by the tree during growth. In other words it is the energy that would have been released if the wood were burnt immediately after harvest.

The acidification potential, eutrophication potential and POCP of the shelf are each around half that of the door. The contribution of different life cycle stages and factors creating these impacts are very similar for both the door and shelf. Of all Wish List pieces, the shelf was the only to use a VOC-free beeswax finish which meant that the coating made zero contribution to POCP.

ENVIRONMENTAL IMPACT CATEGORIES

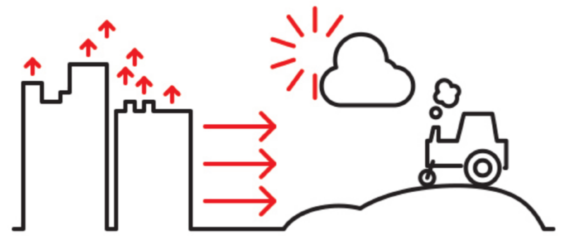


1 PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

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

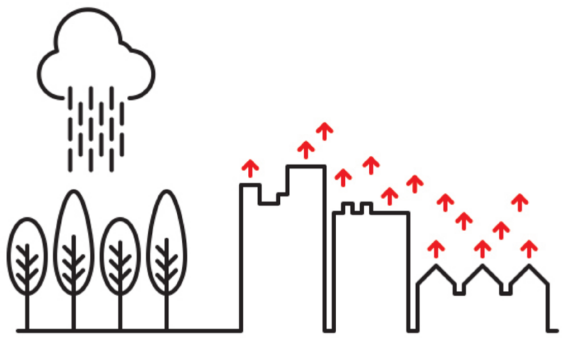


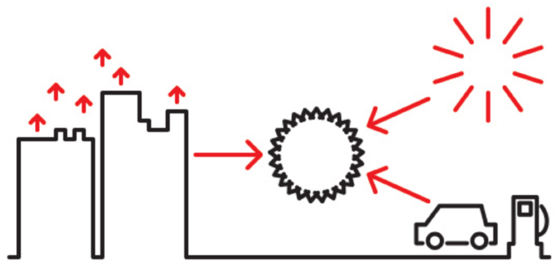
3 GLOBAL WARMING POTENTIAL (GWP)

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.

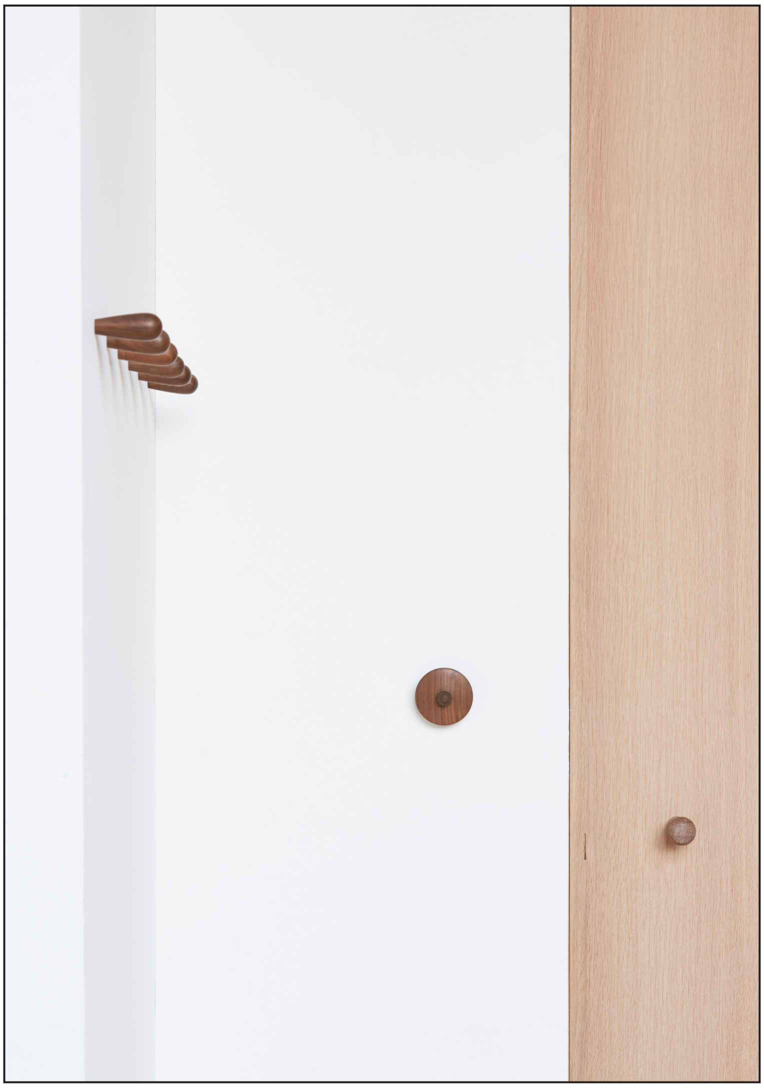
NOTES

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 components, 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).
- 50% of the plywood for the components is discarded and sent for waste incineration with electricity and thermal energy recovery. This is reported in the 'process waste' stage.
- The final disposal of the plywood (the remaining 50%) occurs in the same way but is reported in the 'End of Life' stage
- 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