ENVIRONMENTAL LIFE - CYCLE ASSESSMENT

TULIPIFERA SHARPENERS

PENCIL SHARPENERS BY NORIE MATSUMOTO WITH NORMAN FOSTER

MADE IN AMERICAN TULIPWOOD

SUMMARY

The pencil sharpeners have a very strong environmental profile. Tulipwood is an abundant and under-utilised hardwood which also benefits from relatively quick drying time, resulting in lower emissions during the kilning process. It's very strong, durable and aesthetically attractive, reducing the need or desire for replacement.

The set of four pencil sharpeners is very nearly carbon neutral. The use of wood ensures a big carbon offset due to waste incineration providing energy which substitutes for fossil fuels. The sharpeners only fall short of carbon neutrality due to the relatively large amounts of electrical energy used during fabrication at Benchmark. Given that the LCA measures the very first attempt to manufacturer this product, if this design were ever commercialised it should be a relatively simple matter to increase production efficiency and ensure significant carbon benefits.

WOOD RESOURCE

Tulipwood accounts for 8% of wood volume in the U.S. forest. U.S. government forest inventory data[1] shows that U.S. tulipwood is growing 32.6 million m^3 per year while the harvest is 13.3 million m^3 per year. After harvesting, an additional 19.3 million m^3 of tulipwood accumulate in U.S. forests every year. Tulipwood is being replaced so quickly in the U.S. forest that enough new wood grows to create at least 50 sharpeners every single second.

CARBON FOOTPRINT

At only 18 kilograms of CO_2 equivalent on a cradle to grave basis, the total carbon footprint of the set of four sharpeners is about the same as driving 80 miles (130 km) in the average UK car[2].

Carbon emissions during all stages of material extraction and processing, product manufacturing, and transport are 34 kilograms of CO_2 equivalent. 13 kilograms of CO_2 equivalent are associated with processing and supply of tulipwood to the UK. However these emissions are offset by 16 kilograms of avoided emissions resulting from substitution of fossil fuels through reuse of wood waste.

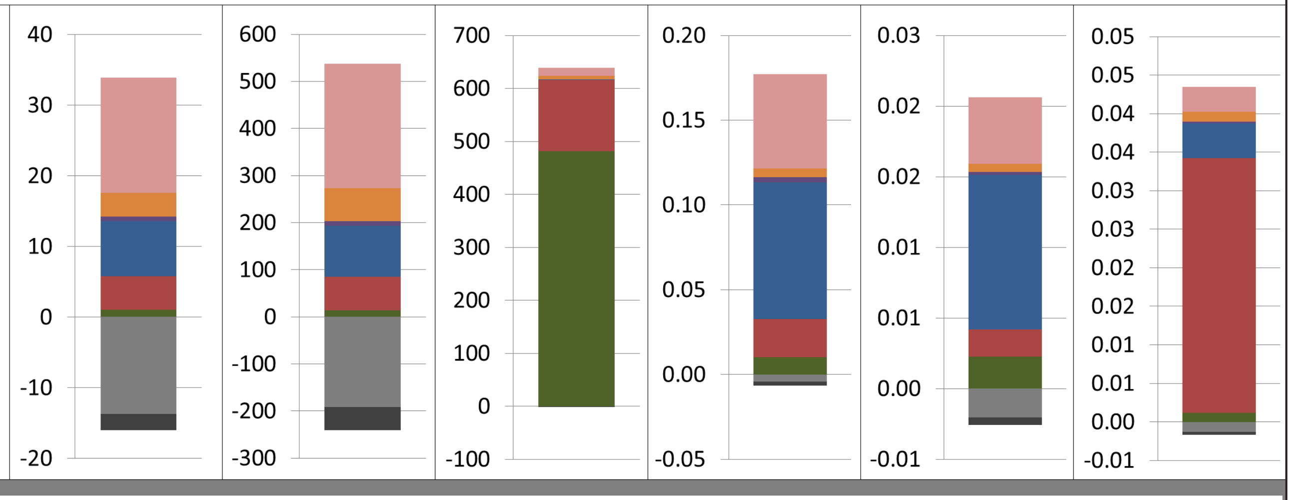
Other than wood supply, 16 kilograms of CO_2 equivalent are due to the electrical energy powering the moulder, sander and saws for fabrication at Benchmark. An additional 3 kilograms of CO_2 equivalent are due to the glues.

A large proportion of the wood required to manufacture the sharpeners 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 from the processing is much greater than the final mass of the product, so the credits from processing are greater than those from end of life.

CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE SHARPENERS

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	18	296	638	0.17	0.02	0.04

Data by process steps



Key Forestry, US processing, Transport, Other wood, Other Materials, Glues & Coatings, UK processing, Process waste, End of Life

OTHER IMPACTS

The total eutrophication potential of the set of sharpeners is 0.02 kg of phosphate equivalent, about the same as caused each year by conventional farming of 8 square meters of land for wheat in the UK[3]. Nearly all eutrophication potential of the sharpeners 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 sharpener's acidification potential of 0.17 kg of SO_2 equivalent is mainly caused by the 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 use of electrical energy from the national grid for UK fabrication is also a significant factor contributing to acidification potential.

The set of sharpeners has a photo-chemical ozone creation potential (POCP) of 0.04 kg of Ethene equivalent. The processing of U.S. hardwoods makes a significant contribution 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 lead to more significant emissions.

The input of renewable energy – 638 megajoules – 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.

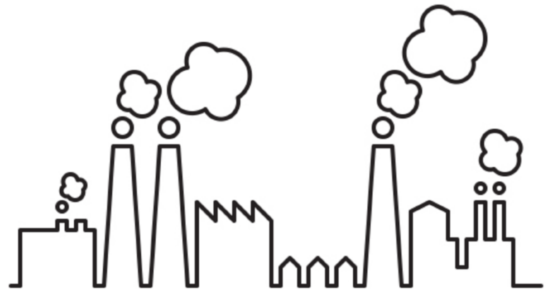
The high proportion of renewable energy attributed to the forestry stage is a peculiarity of life cycle inventory rules for wood products and has nothing to do with the energy used during forestry operations. It is the solar energy that is absorbed by the tree during growth and converted into chemical 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.

The use of a small amount of brass for the metal bits of sharpeners has negligible environmental impact.

MATERIALS USED FOR THE SHARPENERS

Wood materials	Use	Volume (m^3)
American tulipwood sawn 4"	Sharpeners	0.008
American tulipwood sawn 1"	Trays	0.032
Other materials	**Use**	**Quantity**
Osmo clear oil	Finishing	100ml
13 brass sharpeners	Functional elements	260g

ENVIRONMENTAL IMPACT CATEGORIES

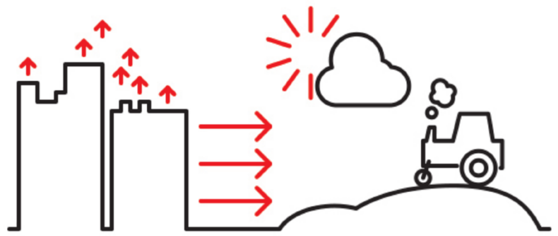


❶ PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

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.

❷ 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

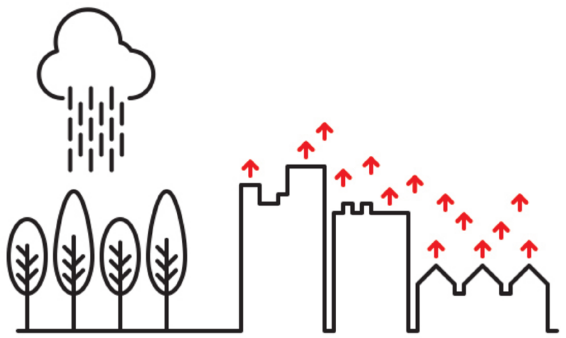


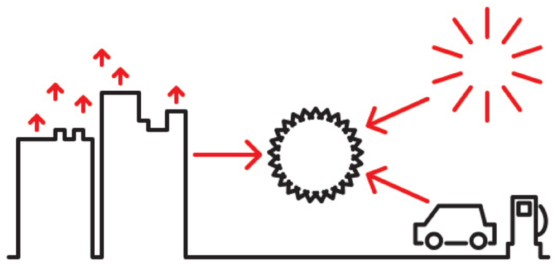
❸ GLOBAL WARMING POTENTIAL (GWP)

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.

❹ 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.





❺ 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.

❻ 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 sharpeners, 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