THE·WISH·LIST

ENVIRONMENTAL LIFE - CYCLE ASSESSMENT

# PAUL'S SHED

SHED BY NATHALIE DE LEVAL WITH PAUL SMITH

MADE IN THERMALLY MODIFIED AMERICAN ASH

## SUMMARY

Unsurprisingly, the large amount of thermally treated ash used for the shed is a dominant factor in the environmental impact, both positive and negative. On the one hand the energy generated from wood waste during manufacturing and at End of Life offset the majority of carbon emissions. With just a few minor alterations – such as a small reduction in the number of metal fixings used - the shed would be carbon neutral on a cradle to grave basis. Use of thermally modified ash also means the shed is highly durable with potential to provide a carbon store for many decades.
On the other hand, the relatively large usage of ash contributes to greater acidification and eutrophication impacts during transport. Kiln drying of ash also contributes to relatively high photo-chemical ozone creation potential (POCP). This highlights the importance of durability as a mitigating factor to reduce the need for replacement.

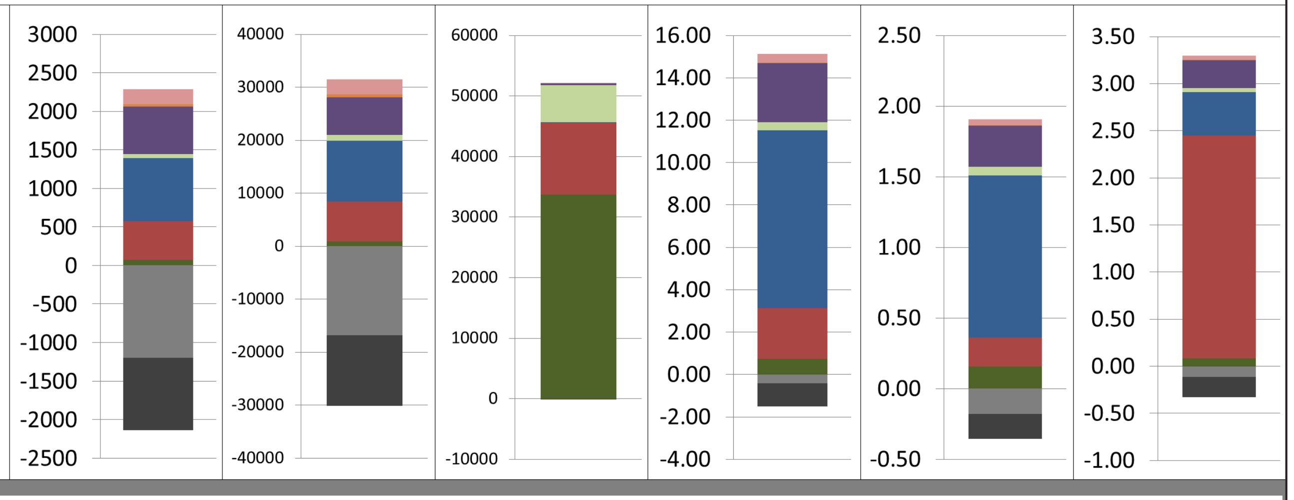
## WOOD RESOURCE

From a forestry perspective, American ash is a good environmental option. Ash accounts for 5% of wood volume in the U.S. forest. U.S. government forest inventory data[1] shows that U.S. ash is growing 12.3 million $m^3$ per year while the harvest is 5.3 million $m^3$ per year. After harvesting, an additional 7.0 million $m^3$ of ash accumulate in U.S. forests every year. It takes less than fifteen seconds for the U.S. hardwood logs harvested to manufacture the shed to be replaced by new growth in the U.S. forest.

## CARBON FOOTPRINT

Cradle to grave, the carbon footprint of the shed is 146 kilograms of $CO_2$ equivalent. That's roughly equivalent to the carbon footprint of driving 655 miles (1055 km) in the average UK car[2].
Carbon emissions during all stages of material extraction and processing, product manufacturing, and transport are 2283 kilograms of $CO_2$ equivalent. 1394 kilograms of $CO_2$ equivalent of the shed's emissions are due to processing and supply to the UK of the 3 cubic meters of thermally treated American ash. However use of wood as the main component of the shed results in a significant offset – in this case 2137 kilograms - of avoided carbon emissions. This is due to substitution of fossil fuels through reuse of the wood waste.
Other than the wood, 452 kilograms of $CO_2$ equivalent are due to the use of steel for fixings and components. The carbon footprint of the glass is low compared to the steel at 165 kilograms of $CO_2$ equivalent. The carbon footprint of fabricating the shed is also quite low at 193 kilograms of $CO_2$ equivalent, mainly due to grid electricity powering the saws at Benchmark. The shed's relatively simple design reduced the need for elaborate processing steps and contributed to more efficient utilisation of material.  Nevertheless, a larger share of the carbon offset is due to reuse of wood waste during manufacture rather than at the End of Life.

CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE SHED

| 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** | 146 | 1354 | 52018 | 13.60 | 1.55 | 2.97 |
| **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 shed is 1.55 kg of phosphate equivalent, about the same as caused each year by conventional farming of 700 square meters of land for wheat in the UK[3]. Nearly all eutrophication potential of the shed is due to nitrate emissions during burning of fuels for transport, particularly during shipping from the United States, and processing of materials. Partially mitigating this effect is the fact that most nitrate emissions occur over the sea rather than over the land where it is particularly damaging to terrestrial ecosystems. Hardly any eutrophication potential is linked to growth of U.S. hardwoods which thrive under natural conditions and very rarely require fertilisers.

At 13.6 kg of $SO_2$ equivalent, the shed's acidification potential is high for a single product. It is mainly due to emissions during shipping of hardwoods from the U.S to the UK and results from the relatively high sulphur content of marine fuels. Other significant contributors to acidification potential are the grid electricity used during hardwood processing in the United States, mainly to power the fans in the kilns, and the use of fossil fuels to manufacture the steel components.

The shed's POCP of 2.97 kg of Ethene equivalent is also significant and is primarily 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. The steel components also make a significant contribution to POCP due to VOC emissions during their production.

The very large input of renewable energy – 52018 megajoules – is due partly to the large amount of thermal energy derived from burning of wood waste during plywood manufacturing and hardwood kiln drying. At least 90% of all thermal energy used for kiln drying in the U.S. hardwood sector is derived from biomass.

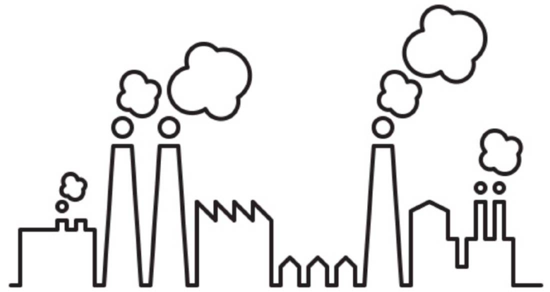
The high proportion of renewable energy attributed to the forestry stage is the solar energy absorbed by the tree during growth. In other words it is the energy that would have been released if the wood were burnt immediately after harvest.

MATERIALS USED FOR THE SHED

| Wood materials | Use | Volume ($m^3$) |
|---|---|---|
| Thermally treated U.S. ash 1"-2" | Main structure | 2.76 |
| Birch plywood | Moisture resistant base | 0.324 |
| Pressure treated softwood | Structural joists for base | 0.28 |
| **Other materials** | **Use** | **Weight (kg)** |
| Steel frames, plates & wires | Components | 200 |
| Glass | Window | 135 |
| Screws, bolts, nails, brackets | Bindings & attachments | 16 |
| Glues | Structural bonding | 3 |
| Beech dominoes | Jointing | 0.2 |
| Casters | Rotating base | 34 units |



# ENVIRONMENTAL IMPACT CATEGORIES

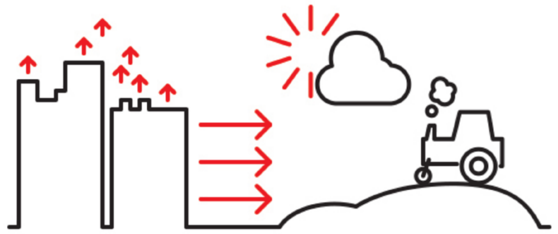


## 1 PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

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

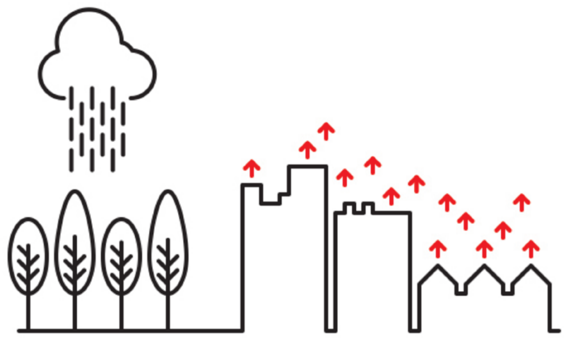


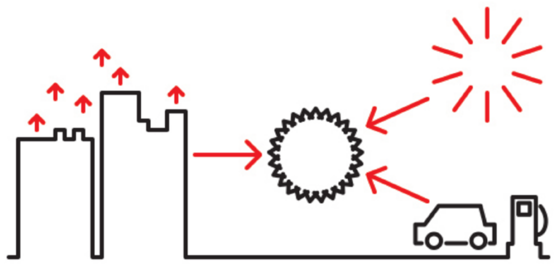
## 3 GLOBAL WARMING POTENTIAL (GWP)

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 shed, 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 base 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*