CHISENHALE PRIMARY SCHOOL PLAYGROUND

DESIGNED BY ASIF KHAN

MAIN CONTRACTOR: ALDWORTH JAMES AND BOND

SUMMARY

The environmental profile of the Chisenhale Primary School playground is heavily influenced by use of 2652 kg of steel for the frames and other elements. This is despite generous assumptions being made that all the steel derives from efficient and relatively close steel mills in Germany[1].
The use of 1495 kg of thermally-modified American tulipwood and ash for the panels mitigates the environmental footprint of the steel in some impact categories, notably Global Warming Potential. Both timbers are readily available in the U.S. forest and have been underutilised in recent years. It takes less than 20 seconds for new growth in the U.S. forest to replace the hardwood logs harvested to manufacture the playground. As trees grow, they remove the main greenhouse gas carbon dioxide from the atmosphere and store the carbon in wood. A total of 2.56 tonnes CO_2 equivalent is sequestered in the American hardwood slats installed in the playground. The thermal-modification process, which enhances the durability of the hardwood, and the quality of the design suggest the structure will remain in place and act as a carbon store for many years. In addition, much of the energy input for production of the American hardwood slats derives from renewables. The waste wood produced during manufacturing is used for energy production, thereby offsetting use of fossil fuels.

WOOD RESOURCE

American tulipwood and ash are some of the world's fastest growing temperate hardwoods. Both species regenerate naturally and are harvested by low intensity selection felling. Both tulipwood and ash are underutilised, a situation the forestry industry can ill afford given its 100-year planting and cropping plan. Establishing a balance between market demand and the dynamic of the forest is essential to achieve true sustainability. U.S. forest inventory data[2] shows that harvests of both tulipwood and ash could be greatly increased without undermining forest integrity or biodiversity. There are 1.02 billion cubic meters of tulipwood in U.S. forests and the species accounts for nearly 8% of all hardwood standing volume in the country. Tulipwood is growing at a rate of 32.5 million m^3 per year, while the harvest is only 12.8 million m^3 per year. After harvesting, 19.7 million m^3 of tulipwood accumulate in U.S. forests every year. Growth rate is at least double harvest rate in every single U.S. state where there are commercial volumes of tulipwood. U.S. forests are host to 670,000 m^3 of American ash which accounts for 5% of U.S. hardwood standing volume. American ash is growing at a rate of 12.1 million m^3 per year while the harvest is 6.1 million m^3 per year. After harvesting, 6.0 million m^3 of ash accumulate in U.S. forests every year.

CARBON FOOTPRINT

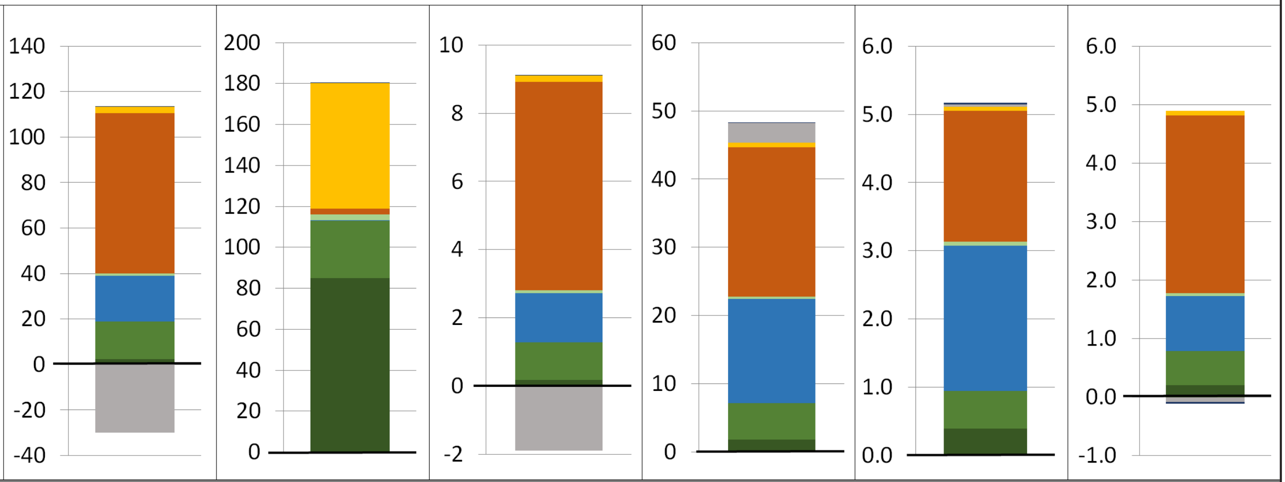
The "cradle-to-gate plus transport" carbon footprint of the playground is 7.23 tonnes of CO_2 equivalent, almost all due to the processes involved in supply of the steel frame. Emissions during processing, fabrication and delivery of the steel parts to site are 6.10 tonnes of CO_2 equivalent and account for 84% of the total carbon footprint of the playground.
For the wood components, total emissions are 3.02 tonnes of CO_2 equivalent, but these are offset by 1.90 tonnes of CO_2 equivalent due to the use of wood waste as an energy source which substitues for fossil fuels. Therefore, the overall carbon footprint of the wood components at point of delivery to the site is 1.13 tonnes of CO_2 equivalent – that is 14% of the total carbon footprint of the playground.
If the additional 2.56 tonnes of CO_2 equivalent stored in the hardwood slats at point of delivery is also taken into account, the wood component of the structure is effectively carbon neutral. The amount of carbon stored in the wood is more than sufficient to offset all the carbon emissions associated with manufacturing and supply of the wood.

Photo Credit:
Hélène Binet

CRADLE TO GATE PLUS TRANSPORT ENVIRONMENTAL IMPACT OF THE CHISENHALE PLAYGROUND

Impact category	Primary energy demand (non-renewable)	Primary energy demand (renewable)	Global Warming Potential	Acidification Potential	Eutrophication Potential	Photochemical Ozone Creation Potential
Unit	GJ	GJ	tonnes CO2-Equiv.	kg SO2-Equiv.	kg Phosphate-Equiv.	kg Ethene-Equiv.
Total	83.7	180.3	7.23	48.3	5.17	4.78

Data by process steps



Key: Hardwood forestry, Hardwood processing, Hardwood transport, Other wood, Steel components, Manufacturing, Process waste, Transport to site

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 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 Chisenhale Primary School playground is a “cradle to gate plus transport” analysis covering all stages from extraction or harvest of materials, material transport, processing, manufacturing and fabrication, transport of the finished products to site at the primary school. It excludes installation, the use phase and end of life.

The wood component of the LCA is very specific to the actual materials used on-site as it builds on a two-year study, commissioned by AHEC and undertaken by thinkstep (formerly PE International), to assess environmental impacts associated with delivery of U.S. hardwood material into world markets . This involved a wide-ranging 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.

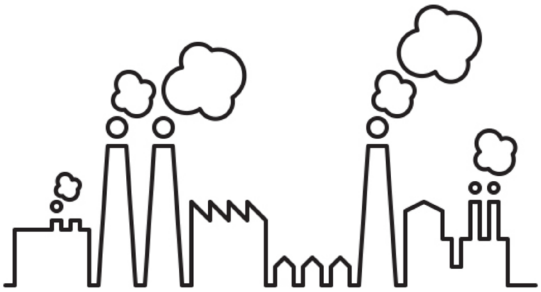
Life cycle inventory data from the LCA of U.S. hardwoods was combined with data gathered during manufacture of the thermally modified hardwood slats by Imola Legno in Italy and of the playground structure by the main contractor - Aldworth, James and Bond - in the UK. It was also combined with thinkstep’s existing life cycle inventory database which covers an expanding range of non-wood materials and product groups. Using thinkstep’s Gabi software for LCA, the data was analysed to quantify environmental impacts.

As is typical in most LCA studies (although less so now for those involving U.S. hardwoods), some far-reaching assumptions and inferences were made in preparing this analysis:

- Data on the precise origin and manufacturing process of the steel used on site was not available. Therefore it is assumed that the steel derives from Germany since around 60% of UK steel consumption is imported and about two thirds of total import derives from other EU countries with Germany the largest single supplier.
- The steel dataset used was one developed by thinkstep named in the GABI database as “DE: Steel sheet HDG”. In addition to all processing stages, the dataset accounts for all transport of raw materials (for example iron ore from Australia, Brazil and Canada, and coal from Australia and Canada). It is assumed that all transport options are by rail or bulk commodity carrier (which are relatively efficient compared to road transport and container ship transport).
- Of total wood input of 2923 kg of tulipwood and 848 kg of ash, 408 kg (14%) and 118 (14%) respectively are allocated to co-products and not assigned to the playground.
- MDF is disposed of in a waste incinerator producing electricity and thermal energy that avoid the UK grid mix and thermal energy from natural gas.
- For tulipwood and ash, total content of the finished structure is 1495 kg (46%) and process waste was 1750 kg (54%).
- 132 kg of MDF was used to create templates during fabrication of the playground structure.
- Mass allocation is used to assign impacts between the main product and offcuts that are reused for other projects.
- Wood waste generated during manufacture of the structure is combusted in a biomass boiler substituting for natural gas.
- The reported carbon footprint (7.23 tonnes of CO2 equivalent) takes no account of, and gives no credit for, delayed carbon emissions due to storage in the hardwood slats or the MDF templates. However, this carbon storage potential of the structure is reported separately (2.56 tonnes of CO2 equivalent).
- Stainless steel screws are considered to be too small to be separately recycled and are also considered to be put through the incinerator and ultimately landfilled with the bottom ash.

These assumptions are based on information gathered from the manufacturers about materials required and their standard procedures for use of waste and from secondary sources about waste-disposal practices in Italy and the UK.

ENVIRONMENTAL IMPACT CATEGORIES

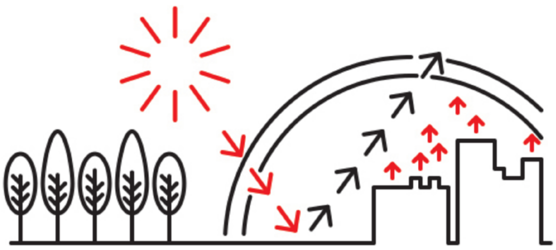


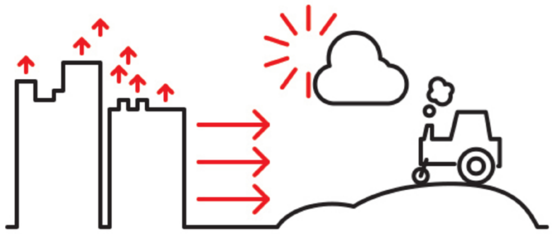
❶ PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

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



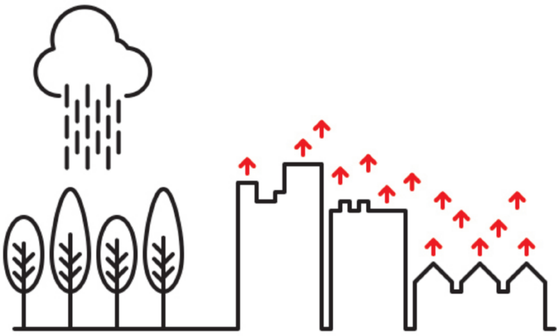


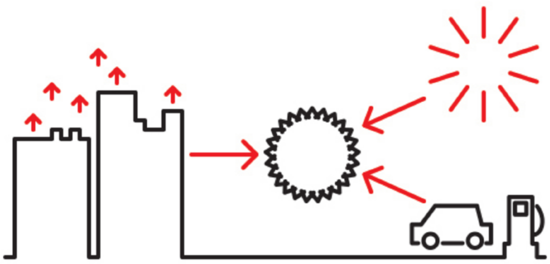
❸ GLOBAL WARMING POTENTIAL (GWP)

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. German origin implies low transport distances to deliver finished steel to the UK, relatively high energy efficiency and high proportion of renewables in the energy mix, and strong industry integration providing good opportunities for efficient use of raw materials and co-products. The German steel LCA datasets also assume transport of raw materials such as ores and coal to manufacturing plants by efficient bulk commodity carriers.
2. Figures based on 2014 data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program at http://www.fia.fs.fed.us/
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.
4. The thinkstep LCA study is available at http://www.americanhardwood.org/fileadmin/docs/sustainability/Final_LCA_Lumber_report.pdf

ENERGY USE

83.7 GJ of non-renewable (fossil fuel) energy was required during all life cycle stages to point of installation at Chisenhale Primary School. That's equivalent to 23000 kWh, a little more than the gas and electrical energy used by an average UK household in a year. 84% (70.6 GJ) of the non-renewable energy consumed was required for the steel components of the playground and 16% (13.1 GJ) for the wood components. In the case of the wood components, 43 GJ of non-renewable energy was consumed during all transport and manufacturing stages but this was largely offset by 30 GJ of energy generated for other industrial processes by burning the wood offcuts created during processing.

A total of 180.3 GJ of renewable energy was required throughout the various life cycle stages of the playground. This includes a large input of solar energy at the Imola Legno facility in Italy where the hardwood slats were manufactured. The AJ&B plant, where the playground was constructed also procures all electrical power from Good Energy, a UK company which matches all the electricity supplied to clients from the national grid with electricity sourced only from certified renewables. In addition at least 90% of thermal energy 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 feature of life cycle inventory rules for wood products and has nothing to do with the energy for forestry operations. It is the solar energy 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.

OTHER IMPACTS

The Eutrophication Potential (EP) of the playground is 5.17 kg of phosphate equivalent, about the same as caused each year by conventional farming of a quarter of a hectare of land for wheat in the UK[3]. Steel components account for 37% of the EP associated with the structure while the hardwood accounts for 63%. However, hardly any EP is linked to growth of U.S. hardwoods which thrive under natural conditions and rarely require fertilisers. Most EP of the playground is due to nitrate emissions during burning of fuels for transport and material processing.

The playground's Acidification Potential (AP) is 48.3 kg of CO2 equivalent. 45% of AP is attributable to the steel components and 55% to the hardwood slats. The AP of the wood component is mainly caused by emissions during shipping of hardwoods from the U.S. to the EU and is due to the high sulphur content of marine fuels.

The playground's Photochemical Ozone Creation Potential (POCP) is 4.78 kg of Ethene equivalent. 64% of POCP is attributable to the steel components and 34% to the hardwood slats. Processing of U.S. hardwoods contributes 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.

TRANSPORT ISSUES

The high proportion of EP and AP due to the wood components relative to the steel components is largely explained by the different methods of transport that dominate each material supply sector. Product-specific information gathered on U.S. hardwoods by thinkstep and AHEC reveals that much internal transport of raw material in the U.S. is by truck and that most lumber is exported by container ship.

Unfortunately, precise product-information on the origin and transport of the steel components used for the playground was not available. Therefore the simplistic assumption is made that all the steel derives from Germany, which is the largest EU supplier of this commodity. A large proportion of raw materials such as iron ore and coal supplied to German steel manufacturers is transported by rail and bulk commodity carrier. Road transport tends to be less energy efficient than rail, and container ships less energy efficient than bulk commodity ships (since the latter typically carry a much larger load with no containers that add weight). As a result the transport element contributes heavily to EP and AP for hardwoods but contributes less to these impact categories for steel.

The environmental impact of the steel would be greater (probably a lot greater) if it were derived from manufacturers located further from the UK, or in countries with an energy mix less dependent on renewable energy than Germany, or where there was less efficient transport networks for supply of both raw materials and finished product.

In this respect it is worth noting that Asian suppliers, particularly in China, are increasing their share of the UK steel market and now account for 16% of UK steel imports and about 8% of UK steel consumption. This has potentially significant implications for the environmental impact of the steel supplied, not only due to transport but also relatively high dependence on coal and other fossil fuels in the energy mix of many Asian countries.