A preliminary assessment of the carbon footprint of American hardwood kiln dried lumber supplied to distributors in the European Union (2nd Edition)

By Rupert Oliver, Forest Industries Intelligence Ltd

Introduction

This paper contains a preliminary estimate of total carbon emissions associated with growing, harvesting and processing American hardwood kiln dried sawn lumber and then transporting from the U.S. mill to distributors yard in the European Union. It draws on the best currently available information to give some idea of the likely total carbon footprint of American hardwoods in the European market, and the relative scale of the contribution of different stages of the processing and supply chain. In the absence of fully representative data, the paper is based on some fairly far-reaching assumptions which, in the interests of transparency, are described in detail below[1].

Assumptions

The following is assumed in making the calculation:

■The amount of carbon stored in dry wood is approximately 50% by weight. When burnt, 1 kg of carbon will produce 3.67 tonnes of carbon dioxide. Therefore carbon sequestrated in wood products is roughly 1.835 kg CO2e/kg.

■Data on carbon emissions during forestry operations and haulage to the mill are taken as an average from two complementary studies together covering the major hardwood producing regions of the Eastern United States. The studies provide estimates of electricity, fuel and lubricant consumption during all operations from seedling production, site preparation, planting, thinning, felling, and haulage to the mill:

(a) Johnson et al (2004)[2] provides data for three South-eastern US forest management regimes: low intensity non-industrial private owner (NIPF); high intensity NIPF; and high intensity industrial. Average consumption figures for these three management regimes are assumed here. Data for electricity use is provided in KwH per cubic foot of extracted timber, and for fuel/lubricant use in gallons/cubic foot.

(b) Elaine E. Oneil et al (2010)[3] provides data for US North Eastern and North Central hardwood composite forest types. Data for electricity use is not included (but can be assumed to be negligible). Data for fuel and lubricant use is provided in litres per m3 of extracted timber.

■Based on US EPA data: (a) an average 1.341 pounds (0.61 kg) of CO2 per KwH is emitted in the United States; and (b) a (US) gallon of gasoline emits 8.8 kg of CO2, equivalent to 2.33 kg/litre.

■No fertiliser is applied, in line with common regeneration practices in the American hardwood sector.

■Unseasoned hardwood logs have an average density of 800 kg/m3.

■A conversion factor from logs to sawn lumber of 50% by volume (i.e. 1 tonne of logs must be transported from forest to sawmill to produce 0.5 tonne of sawn lumber).

■Figures for emissions during processing at the US mill are taken from Bergman and Bowe (2007)[4] which compiles data collected from 20 hardwood sawmills in north-eastern United States. Bergman and Bowe give average figures for biomass and fossil carbon dioxide production of 428 kg per m3 and 139 kg per m3 respectively. Assuming an average wood density for kiln dried American hardwood sawn lumber of 600 kg/m3 (about mid way between white oak at 735 Kg/m3 and tulipwood at 476 kg/m3) these figures imply emissions of 0.713 kg CO2e/kg from the burning of biomass and 0.232 kg CO2e/kg from the burning of fossil fuels.

■Specific figures for emissions during hardwood processing in other parts of the US could not be identified when preparing this review. However data compiled in Maureen E. Puettmann et al (2010)[5] suggests that the proportion of biomass used from harvest site through to output of hardwood lumber in the NE US is not unusual compared to other forest regions and wood products.

■Transport distance of 500km by road to port in the United States – since a large proportion of US hardwood production is in coastal rather than interior regions, this is likely to exceed the distance required in most cases.

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■Transport distance of 7123km by sea. This is the weighted average distance of sea transport for all US hardwood lumber exports to EU destinations between 2003 and 2009. It has been derived by analysis of US hardwood lumber export data by port and European destination (sourced from www.ustrade.com). Transport distances for individual products range from a minimum of 5300km (e.g. NYC to Lisbon) to a maximum of 18000 km (e.g. Seattle to Athens). However since 96% of US hardwood lumber exports to the EU are from the East Coast, the weighted average is towards the lower end of this range.

■Transport distance of 300km by road to manufacturer in Europe. Although US hardwoods are occasionally transported over large distances in the EU (for example wood imported into Hamburg for delivery to a manufacturer in Warsaw would require a road trip of 750 km), the vast majority of manufacturers in all the major EU markets for US hardwoods are located much closer to ports. The figure of 300 km is likely to be well in excess of the average distance travelled.

■Emissions from sea transport vary widely depending on the type of ship in addition to other factors such as capacity utilisation. PE International suggest that emissions for container shipment over distances identified here are typically in the region of 13 kg CO2e/t-km. However use of universal bulk carriers over these distances could bring the figure down to only around 2.5 kg (personal comm, PE International, March 2010). PE International have been engaged by AHEC to assess in more detail this and other aspects of the CO2 profile of American hardwoods. In the meantime, this analysis uses PE International's high figure of 13 kg CO2e/t-km for container shipment.

■PE International's parameterized transport model for trucks indicates that truck emissions vary widely depending on the types and ages of truck used, payload, profile of road, capacity utilization, way back empty or with load. For the length of journey indicated here, PE International suggest figures in the range of around 50g to 76g CO2e/t-km for truck emissions. The mid point of 63g CO2e/t-km is used for this analysis.

Calculation

Factor	Working	Carbon sequestration	Emissions
		kg CO2 equivalent per kg of product	
Carbon storage in wood	Volume of carbon in 1 kg wood (0.5kg) X carbon dioxide equivalent (3.67)	-1.835	
Emissions from fuel/lubricant use during forestry operations and haulage to mill	Johnson et al indicate consumption of fuel & lubricants = 0.058 gallons/ft3 = 0.51 kg CO2/ft3 = 18 kg CO2e/m3 = 0.0225 kg CO2e/kg. Divide by 0.5 to take account of conversion to sawn lumber = 0.045 Oneil et al indicate consumption of fuel & lubricants = 17.304 litres/m3 = 40.32 kg CO2e/m3 = 0.0504 kg CO2e/kg. Divide by 0.5 to take account of conversion to sawn lumber = 0.1008. Average for the two figures = 0.0729		0.0729
Emissions from electricity use during forest operations	No figures provided by Oneil et al, however Johnson et al report 0.0037 KwH/ft3 = 0.0023 kg CO2e/ft3 = 0.08 kg CO2e/m3 = negligible amounts per kg of product.		0
Emissions from burning of fossil fuel during processing at the US mill	Derived from Bergman and Bowe (2007) study of 20 north-eastern sawmills.		0.232
Emissions from burning of biomass (i.e. mainly wood waste) during processing at US mill	Bergman and Bowe report biomass emissions of 0.713 kg CO2e/kg. These are considered carbon neutral. Although there will be carbon emissions associated with delivery of wood biomass to the mill's energy plants, it is assumed in this instance that biomass is derived from the off-cuts of the sawn lumber production process for which all emissions have been accounted for. Note that this calculation assumes no allocation of carbon emissions of these off-cuts to other products.		0
Emissions during transport from mill to port in the US	500km X 63g = 31500g = 31.5 kg CO2/tonne of product		0.0315
Emissions during sea transport	7123km X 13g = 92599g = 92.6 kg CO2/tonne of product		0.0926
Emissions during transport from port to European distributor	300km X 63g = 18900g = 18.9 kg CO2/tonne of product		0.0189
Totals		**-1.835**	**0.4479**
Overall emissions	**Emissions of 0.4479 less 1.835 avoided emissions due to storage in wood**	**-1.3871**	

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Observations

■Sequestration of carbon during the growth of the tree more than offsets the total carbon emissions resulting from harvesting, processing and transporting of American hardwoods to European distributors.

■The extent and way in which carbon sequestration during growth may be "credited" varies under different carbon footprint standards. The UK PAS2050 standard credits a proportion of sequestered carbon dependent on the life time of a product. For example, 0.19% of the sequestered carbon may be credited for a product in use for 25 years, rising to 50% for a product in use 50 years. Drawing on the figures presented here, an American hardwood product would have to remain in use in the UK for around 26-27 years in order to be considered carbon neutral under the terms of PAS 2050.

■Even if the considerable benefits of carbon sequestration in American hardwood products were not considered, emissions of 0.448 kg CO2e/kg compare very favourably against other materials - including most domestic European wood and non-wood products and recycled materials. To illustrate, comparative data from the UK is provided in the table overpage.

■Transport is a relatively minor factor in the overall carbon footprint of American hardwoods. This is particularly true of ocean transport. Transporting American hardwoods by ship across 6200 km of the Atlantic requires about the same amount of energy as an overland journey of 1200 km. In fact a complete circumnavigation of the world by sea (40000 km) would add only 0.52 kg CO2e/kg to the overall footprint and would be readily offset by the carbon sequestered in the wood product.

■Heavy dependence on biomass rather than fossil fuel energy during processing is a particularly important factor in keeping the overall carbon footprint of American hardwoods low.

Embodied carbon of common building materials in the UK

Material	Embodied carbon (kg CO2e/kg)[b]
Virgin aluminium	11.45
Stainless steel	6.16
Wool	5.48
Carpet	3.89
Virgin steel	2.75
Plastics	2.53
PVC	2.41
Vinyl flooring	2.29
Recycled aluminium	1.69
Glass	0.86
Cement	0.83
Plywood[a]	0.81
Glulam[a]	0.65
Cement with 25% fly ash replacement	0.62
Ceramic tiles	0.59
MDF[a]	0.59
Timber consumed in the UK (average) [a]	0.48
American hardwood KD sawn (incl. transport from U.S. to the EU) [a]	**0.45**
Recycled steel	0.43
Cement with 50% fly ash replacement	0.42
American hardwood KD sawn (excl. transport from U.S. to the EU) [a]	**0.30**

(a) All figures for timber exclude carbon sequestered during forest growth. If carbon sequestration is included, timber products have a negative carbon balance (i.e. they store more carbon than they consume during manufacture).
(b) Source for products other than American hardwoods: University of Bath, UK, "Inventory of Carbon Emissions" (ICE, Version 1.6a, 2008). Available at: http://people.bath.ac.uk/cj219/

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Notes and references

1. AHEC has commissioned a much more comprehensive independent study in line with relevant national and international carbon footprinting standards from PE International, a company specialising in LCA-related wood. The PE International study will replace this preliminary analysis when complete, expected in late 2011. In the meantime, PE International reviewed this paper in March 2011 and made recommendations for its improvement. However this analysis remains the work of Rupert Oliver and any responsibility for errors lies with him. Nor is any claim made with respect to conformance of this analysis to standards for carbon footprint analysis.

2. Johnson et al, 2004, CORRIM: Phase I Final Report, Module A, Forest Resources Pacific Northwest And Southeast - Review draft of June 1, 2004. Available for download at: http://www.corrim.org/reports/final_report_2004/Module%20A%20-%20For_Resources_June%2017_2004_FINAL.pdf

3. Elaine E. Oneil et al, 2010, Life Cycle Impacts of Inland Northwest and Northeast/North Central Forest Resources, Wood and Fiber Science, 42(CORRIM Special Issue), 2010, pp. 29–51

4. Bergman and Bowe, 2007, Environmental Impact of Producing Hardwood Lumber Using a Life-Cycle Inventory. Proceedings of the 10th International IUFRO Division 5, Wood Drying Conference, August 26-30, 2007, Orono, Maine, USA. p. 180-185. Available for download at: http://www.corrim.org/reports/pdfs/woodfiberscience_bergman_bowe_2008.pdf

5. Maureen E. Puettmann et al, 2010, “Cradle to Gate Life Cycle Inventory of US Wood products production: Corrim Phase 1 and Phase II products” contained in Wood and Fiber Science, 42 (CORRIM Special Issue), 2010, pp. 15–28. http://www.corrim.org/pubs/reports/2010/swst_vol42/15.pdf

6. Figures calculated here for carbon emissions for all phases from forestry operations through processing at the US mill are comparable to average figures calculated by CORRIM for US “structural hardwood lumber” which take account of factors such as allocation to different end-uses. Corrim figures for this commodity are given as 0.44 kg CO2e/kg of energy derived from biomass and 0.19 kg Co2/kg of energy derived from fossil fuels (contained in Maureen E. Puettmann et al, 2010).

Rupert Oliver
Forest Industries Intelligence Limited
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