Life-Cycle Inventory of Hardwood Lumber School Chair

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1 Introduction

Life Cycle Assessment (LCA) is a tool designed to quantify and evaluate a broad scope of environmental impacts from the selected life cycle of a given product. Life Cycle Assessment is one of the significant ways for the wood industry to promote the environmentally-friendly properties of wood with scientific evidence [1]. A classic LCA project is composed of three stages: defining scopes and goals, Life Cycle Inventory (LCI), and procuring Lifecycle Impact Analysis (LCIA).

Recent studies of LCA on wood focused mainly on investigating the LCI of composite materials, and few of them pay attention to final wood products. Here we post an LCA case study for a wooden chair. The design of this chair and manufacturing process has been thoroughly tested through laboratory modeling at Purdue's Wood Research Laboratory and through a case study implementation of a manufacturing facility used to produce 50 furniture sets performed by Purdue Wood Research Laboratory in collaboration with the Institute of Technology of Costa Rica. Figure 1 is the exploded view of this chair, called 14" chair.

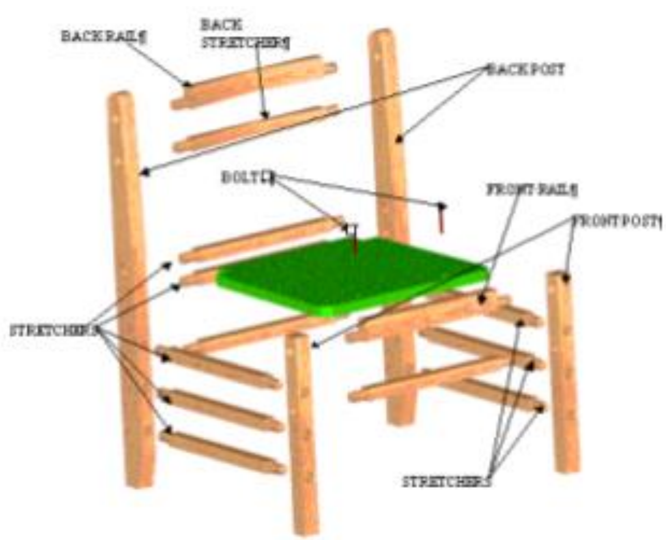

Figure 1: Exploded view of 14" chair, showing all components

2 Scope, Goals and Functional Units

Goal of this study is to 1) provide a production inventory for school furniture and 2) benchmark environmental impacts of the lab made wooden chair. Figure 2 is the diagram of production system boundary. Production inventory is provided in section 3, and general gate-to-gate LCIA is provided in section 4.

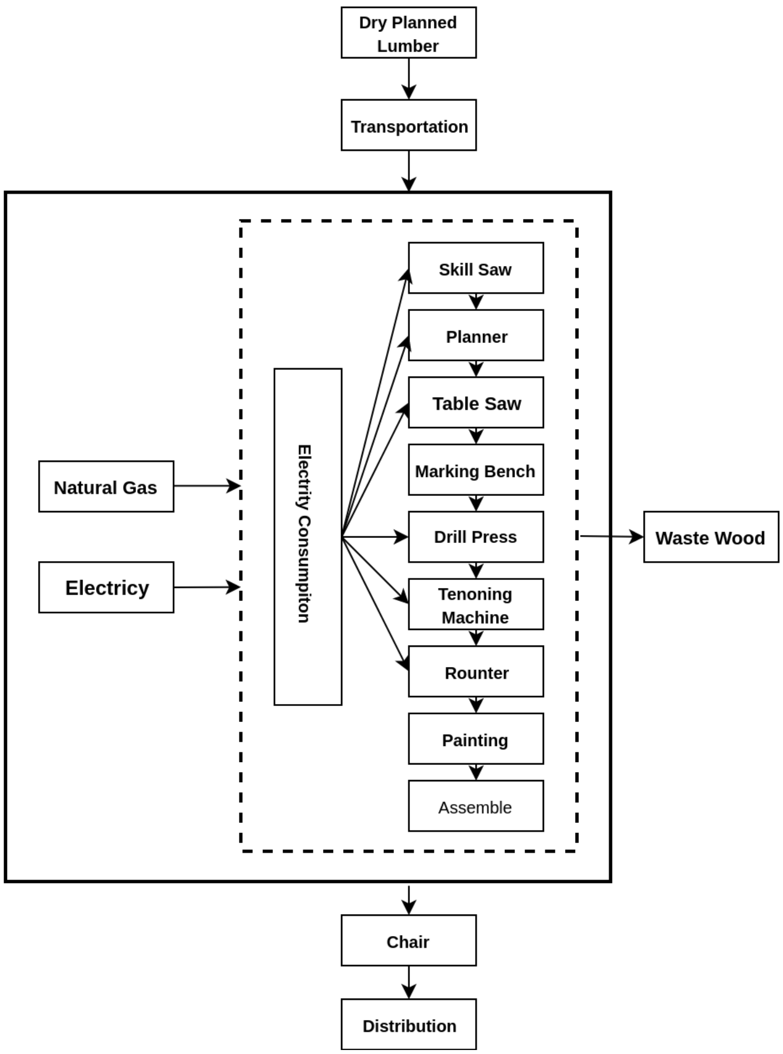

Figure 2: Production LCI system boundary. The dash line area are the main production process and bold black line area is the system boundary

3 Life Cycle Inventory (LCI)

3.1 Material consumption

Produced in laboratory chair model shows that raw material inputs for this chair, including waste wood not used in the final product, was 496.8 in^3 cutting units of lumber, or 3.45 board feet (BF). Only 56% of used lumber is found in the final product, while the rest is treated as the waste. Table 1 and Table 2 below show details of raw material input and output.

Table 1: Major Material Inputs

Material	Functionality	Quantity
Hardwood	Stretcher	168 in^3
	Legs	160.8 in^3
	Seat	168 in^3
	Total	496.8 in^3
Polyvinyl acetate	Glue	1.28 oz

Table 2: Major Material Output

Material	Functionality	Quantity
Hardwood	Chair	1
Waste Hardwood	Wood Wastes	218.5 in^3

3.2 Energy Consumption

Table 3 shows the operation times and energy consumption of each machine for production of a single chair. Here, the energy consumption is computed based on the power of the machine and operation times. Generally, it is not easy to track idle power, so we assume that the idle power is half of the full power. Dust Collector contributes most to the energy consumption and achieves high uncertainty for mass production due to the nature of non-linearity in the mass production of wood products.

Table 3: Operation times and energy consumption of each machine for producing a single chair.

Machine	Cutting Time (s)	Idle Time (s)	Energy (kwh)
Band Saw	87	40	0.045
Radial Arm Saw	28	21	0.024
Jointer	65	65	0.040
Planer	34	0	0.071
Table Saw	82	52	0.112
Drill Press	600	792	0.103
Tenon Machine	240	139	0.048
Bent saw - trim	200	152	0.114
Orbital Sander	30	0	0.002
Hand Router	150	0	0.009
Dust Collector	150	198	1.032
Total			**1.6**

4 Life Cycle Impact Assessment (LCIA)

A gate-to-gate life cycle impact analysis is provided based on USLCI [2] database and TRAIC
2.1 [3, 4]. The system boundary is extended to the log as the raw material. In order to simplify this scenario, we assume that there is no waste treatment for wood wastes, and the economic allocation method is used. Table 4 is the overall output.

Table 4: Gate-to-gate Lifecycle impact analysis for a wooden chair

Impact category	**Refernce**	**Result**
Acidification	kg SO2 eq	7.57×10^{-2}
Carcinogenics	CTUh	2.03×10^{-6}
Ecotoxicity	CTUe	1.28×10^{-1}
Eutrophication	kg N eq	1.82×10^{-3}
Fossil fuel depletion	MJ surplus	5.86×10^{-2}
Global warming	kg CO2 eq	4.86×10^{-1}
Non carcinogenics	CTUh	2.63×10^{-7}
Ozone depletion	kg CFC-11 eq	$0.00 \times 10^{+0}$
Respiratory effects	kg PM2.5 eq	7.69×10^{-3}
Smog	kg O3 eq	$1.02 \times 10^{+0}$

To report just the LCIA of single product is meaningless. In next publication, several factors that contribute to the changes LCIA of wood products productions are investigated.

References

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[3] Jane Bare. Traci 2.0: the tool for the reduction and assessment of chemical and other environmental impacts 2.0. *Clean Technologies and Environmental Policy*, 13(5):687–696, 2011.

[4] Jane C Bare. Traci: The tool for the reduction and assessment of chemical and other environmental impacts. *Journal of industrial ecology*, 6(3-4):49–78, 2002.