Generic Wood Framing

Product Selection and Description

Wood framing is the most common structural system used for non-load-bearing and load-bearing interior and exterior walls, and consists of lumber and specific applications of treated lumber. The load-bearing walls support floors, ceilings, roof and lateral loads, and nonbearing walls carry only their own weight. Interior walls can be either non-load bearing or load bearing, whereas all exterior walls should be considered load bearing. Exterior walls are comprised of one or two top and bottom plates and vertical studs. Sheathing or diagonal bracing ensures lateral stability. When the wall is on a concrete foundation or slab, building code requires that the sill or sole plate (also called bottom plate) that is in contact with the concrete must be treated wood.

In general, dimensions for framing lumber are given in nominal in, that is, 2x4 and 2x6, but the actual dimensions of a 2x4 are 3.8 cm x 8.9 cm (1.5 in x 3.5 in) and of a 2x6, 3.8 cm x 14 cm (1.5 in x 5.5 in). Framing lumber must be properly grade-marked to be acceptable under the major building codes. Such grade marks identify the grade, species or species group, seasoning condition at time of manufacture, producing mill, and the grading rules-writing agency.

Wood studs are produced in a sawmill, where harvested wood is debarked and sawn into specific dimensions. The lumber is then dried in a controlled environment until the desired moisture content (between 12 % and 19 %) is reached. Framing lumber may be treated with preservatives in order to guard against insect attack or fungal decay. Treated lumber is used for any application where wood is in contact with concrete or the ground. All wood, including framing, used in places with serious termite problems, such as in Hawaii, must be treated.

The functional unit of comparison for BEES framing alternatives is 0.09 m^2 (1 ft^2) of load-bearing exterior wall. The wood-framed wall consists of wood studs placed 41 cm (16 in) on center, and has a service life of 75 years. While the exterior wall is constructed as an assembly with sheathing components and insulation, for the BEES system, only the framing material—either treated or untreated wood--is accounted for, not the full assembly.

Flow Diagram

The flow diagram below shows the major elements of the production of this product, as it is currently modeled for BEES.

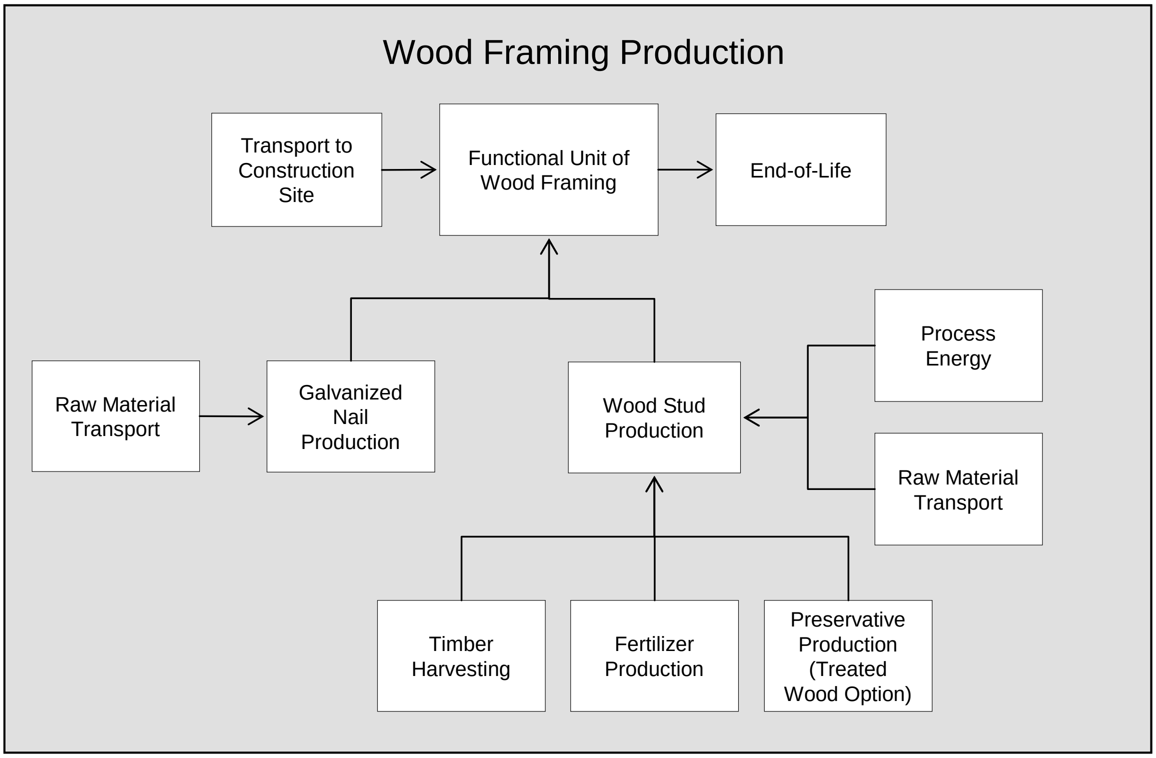

Figure 1: Wood Framing System Boundaries

Raw Materials

For BEES, data were collected for the harvested trees used to produce the dimension lumber necessary for framing load-bearing walls. The lumber is primarily produced in the Pacific Northwest (PNW) and the Southeastern United States (SE). For PNW the species of wood used are Douglas Fir and Western Hemlock, while for SE the wood species is Southern Yellow Pine, which is actually a group of six different softwood species.

The data to grow and harvest softwood logs for a composite forest management scenario for PNW and SE is found in a study by CORRIM.[1] The growing and harvesting of wood includes a mix of low-, medium-, and high-intensity managed timber. Energy use for wood production includes electricity for greenhouses to grow seedlings, gasoline for chain saws, diesel fuel for harvesting mechanical equipment, and a small amount of fertilizer. Emissions associated with production and combustion of gasoline and diesel fuel, and those for the production and delivery of electricity, are based on the U.S. LCI Database. Fertilizer production data is adapted from European data in the U.S. LCI Database. Electricity use for greenhouse operation is based on the grids for the regions where the seedlings are grown, while the U.S. average electricity grid is used for fertilizer production. BEES adopts the CORRIM study's equally-weighted average of forest management practices in PNW and SE. The weight of wood harvested for lumber is based on an average oven-dry density of 510 kg/m^3 (31.8 lb/ft^3).

BEES modeling accounts for the absorption of carbon dioxide by trees as they grow; the carbon becomes part of

[1] Bowyer, J., et. al., *Phase I Final Report: Life Cycle Environmental Performance of Renewable Building Materials in the Context of Residential Construction*. (Seattle, WA: Consortium for Research on Renewable Industrial Materials-- CORRIM, Inc./University of Washington, 2004). Found at: http://www.corrim.org/reports; data also submitted to US LCI Database.

the wood, and the oxygen is released to the atmosphere. The "uptake" of carbon dioxide from the atmosphere during the growth of timber is about 1.84 kg (4.06 lb) of carbon dioxide per kilogram of harvested wood (in oven-dry weight terms).

Chromated Copper Arsenate (CCA), the lumber treatment assumed in previous versions of BEES, is no longer permitted for use in the United States. An article from the Treated Wood Council website reports that alkaline copper quaternary (ACQ), a copper-based preservative, is the most popular replacement preservative for CCA.[2] This contains 66.7 % copper oxide and 33.3 % didecyldimethyl ammonium chloride. The data used in BEES for copper oxide is based on European data for copper production, provided by the SimaPro database. For lack of better available data, proxy data was used to represent didecyldimethyl ammonium chloride; esterquat, a type of quaternary ammonium, was used as the proxy, and its production data comes from a European study on detergents.[3] The treated wood in BEES is assumed to contain 4.0 kg/m^3 (0.25 lb/ft^3) ACQ.[4]

Manufacturing

Energy Requirements and Emissions. The energy requirements allocated to the production of softwood lumber for wood framing are listed in the Table below. These requirements are based on average manufacturing conditions in the PNW and SE regions of the United States. The energy comes primarily from burning wood and bark waste generated in the sawmill process. Other fuel sources include natural gas for boilers, and propane and diesel for forklifts and log haulers at the sawmill. The production and combustion of the different types of fuel are based on the U.S. LCI Database. The electricity grid used is an average by fuel breakdown for both regions.

Table 1: Lumber Production Energy

Energy Carrier	***Quantity per lb Lumber in SE***	***Quantity per lb Lumber in PNW***
Electricity	1.80E+05 J (0.05 kWh)	2.88E+05 J (0.08 kWh)
Natural Gas	4.81E-08 L (1.7 E-09 ft^3)	23 L (0.82 ft^3)
Diesel fuel	0.56 mL (1.5 E-04 gal)	0.98 mL (2.6 E-04 gal)
Kerosene	0.001 mL (3.8 E-07 gal)	--
LPG	7.95E-05 mL (2.1 E-08 gal)	2.69E-04 mL (7.1 E-08 gal)
Gasoline	0.05 mL (1.2 E-05 gal)	0.06 mL (1.7 E-05 gal)
Hogfuel/Biomass (oven-dry basis)	118 g (0.26 lb)	73 g (0.16 lb)

The allocated process-related air emissions from lumber production are based on the CORRIM study and reported in the Table below. Allocation is based on mass and a multi-unit process analysis to correctly assign burdens. Note: In the BEES model, CO_2 generated by combustion of biofuel (hogged wood fuel) and fossil fuel are tracked separately since CO_2 from biomass is considered environmentally impact-neutral by the U.S. EPA, and as such is not considered when determining the Global Warming Potential impact.

[2] Frome, A., "Wood Treaters Switch to New Chemical," *TimberLine Online Newspaper* (April 2004). Found at: http://www.treatedwood.com/news/industry_articles/new_chemical_040104.pdf.

[3] Dall'Acqua, S., et al., Report #244 (St. Gallen: EMPA, 1999).

[4] Southern Pine Council, "Table 12: AWPA Standards for Softwood Lumber & Plywood," *Southern Pine Use Guide* (Kenner, LA: Southern Pine Council, 2003), pp. 17. Found at: http://www.southernpine.com/awpatable1_03.pdf.

Table 2: Lumber Production Emissions

Air Emission	*Quantity per lb Lumber from SE*	*Quantity per lb Lumber from PNW*
Particulates (unspecified)	0.44 g (9.7 E-04 lb)	0.01 g (3.0 E-05 lb)
VOC (unspecified)	0.50 g (1.1 E-03 lb)	0.09 g (1.9 E-04 lb)

Treating Wood. Data for treating wood comes from a treated lumber producer.[5] Lumber is put into a vacuum chamber where air is removed from the wood cells. Preservative is pumped into the chamber, and with the pressure in the chamber raised, the preservative is forced into the wood. At the end of the treatment, a vacuum removes excess preservative from wood cells.

Transportation. Sawmills are often located close to tree harvesting areas. For transportation of logs to the sawmill, CORRIM surveys report an average truck transportation distance of 103 km (64 mi) for harvested wood. The delivery distances are one-way with an empty backhaul. For preservative-treated lumber, truck transportation of 322 km (200 mi) is assumed for transport of the preservative.

Transportation

Transportation of wood framing by heavy-duty truck to the building site is modeled as a variable of the BEES system.

The weight of wood shipped includes its moisture content. For the shipping weight of lumber, the oven-dry density of lumber, 510 kg/m^3 (31.8 lb/ft^3), plus its moisture content of 19 % (an additional 97 kg of water), yields a shipping weight of 607 kg/m^3 (37.9 lb/ft^3). The ACQ-treated lumber is usually shipped green, so a 40 % to 60 % moisture content is assumed.

Installation

Installation of wood framing is assumed to be done primarily by manual labor, so there are no installation emissions. It is assumed that wood studs are placed 16 in on center and are fastened with galvanized steel nails. Production of the galvanized steel for nails is based on data from the International Iron and Steel Institute.[6]

At installation, 5 % of the product is lost to waste, and all of this waste is disposed of in a landfill. It is assumed that 0.04 kg (0.09 lb) of galvanized nails are needed to install the framing.

Use

Based on U.S. Census data, the mid-service life of a wood-framed house in the United States is over 85 years. To be conservative, CORRIM assumes a life of 75 years for the residential shell, including wood framing. The product is therefore assumed to have a useful life of 75 years.

There is no routine maintenance for the framing over its lifetime. The building envelope (roof and siding) should be maintained to ensure water tightness and prevent water damage to the shell.

End of Life

All the wood framing is assumed to be disposed of in landfill at end of life. The practice of recycling is increasing, but data are not available to quantify this practice.

[5] See www.follen.com/faq.html#q3.

[6] Life Cycle Inventory Data Sheet for Steel Products issued to First Environment in January 2006. Data represent the years 1999-2000.

References

Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO. Found at: http://www.nrel.gov/lci/database.

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Industry Contacts

Jim Wilson, Oregon State University/CORRIM, Inc. (August 2005-Jan 2006)