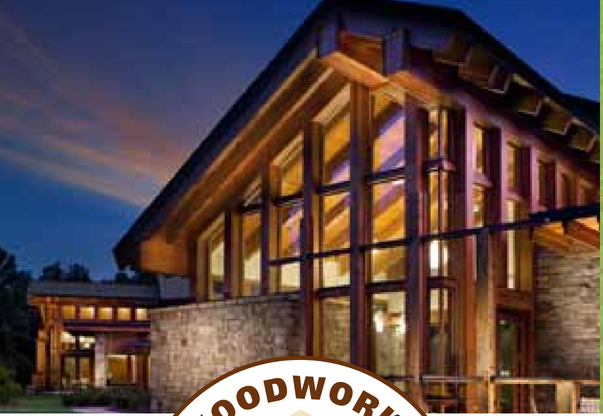

Wood and Carbon Footprint

WOOD DESIGN & BUILDING SERIES

WOODWORKS FOR NON-RESIDENTIAL CONSTRUCTION

Would you like to know how much carbon is stored in your wood building project? What about the greenhouse gas emissions avoided by not using steel or concrete? Or what these savings equate to in everyday terms such as vehicle emissions and home operational energy? If you'd like to calculate the carbon benefits of a U.S. non-residential or multi-family building project, email your request to resources@woodworks.org.

Earn one AIA/CES LU (HSW/SD) by reading this document and taking a short online quiz. For details and learning objectives, visit the Online Training Library at *woodworks.org*. WoodWorks is an approved AIA provider.

CONTINUING EDUCATION AIA

Given the impact of buildings on U.S. energy consumption and related emissions, design professionals are uniquely positioned to reduce greenhouse gases in the atmosphere by creating high-efficiency structures. However, in addition to operational energy efficiency, designing a building in wood can significantly lower its carbon footprint.

Forests and wood products reduce atmospheric levels of greenhouse gases in several ways:

- Most people know that trees clean the air by absorbing carbon dioxide (CO_2). They release the oxygen (O_2) and use the carbon (C) to produce sugars for growth, incorporating it into their leaves, twigs, solid woody stems and surrounding soil.
- Lesser known is the fact that wood products continue to store much of this carbon, which is kept out of the atmosphere for the lifetime of the product—even longer if the wood is reclaimed and used elsewhere. Wood is about 50 percent carbon by dry weight.
- Wood is produced using energy from the sun as opposed to fossil fuels. Manufacturing processes associated with wood products also require less fossil fuel-based energy and are responsible for far less greenhouse gas emissions than the manufacture of other major building materials.
- Forest and mill residues and other woody biomass are commonly used by the forest industry as a clean source of renewable bioenergy, further reducing emissions.

Increasingly, governments around the world are implementing policies that recognize these benefits and encourage greater use of both wood in buildings and renewable biomass to meet society's broader energy needs.

Supporting greater wood use, there is also a trend toward taller wood buildings that store even more carbon. In addition to the four, five and six-story podium designs that have become popular as a way to provide increased density at lower cost, a pending study[i] is expected to confirm the feasibility of a 20-story wood building in Vancouver, Canada. As of March 2011, the world's tallest modern wood building is a UK structure that includes eight stories of cross laminated timber over one story of concrete.

The Role of Forests: Growth, Harvest and Renewal

Young, vigorously growing trees have a higher rate of CO_2 absorption than mature trees. Trees typically grow in what is described as a sigmoid curve, with growth rate being greatest in the early to middle years and dropping off as they reach maturity. In most U.S. and Canadian forests, this drop occurs when a tree is between 60 and 150 years old, depending on the species and environmental factors.

When a tree is harvested, about half the carbon stays in the forest and the rest is removed in the logs, which are then converted into forest products. Some carbon is released when the forest soil is disturbed during harvesting, and the roots, branches and leaves left behind release carbon as they decompose. However, once the harvested area is regenerated, either naturally or by planting or seeding, the forest once again begins to absorb and store carbon.

In the case of unmanaged forests, old trees will eventually stop capturing new carbon. They continue to store the carbon already absorbed until they start to decay—at which point they begin releasing the carbon in the form of CO_2.

THE CUMULATIVE EFFECT OF STORED CARBON

The amount of carbon currently stored in U.S. wood products (including those in landfill sites) is estimated at 3.5 billion metric tons—but it's the cumulative impact over time that is most impressive. The accumulation of carbon in U.S. wood products is about 60 million metric tons each year. Most of this resides in the nation's housing stock, 90 percent of which is wood-frame construction. Assuming that a greater number of homes and non-residential wood buildings are built each year than deconstructed, the amount of stored carbon can be expected to grow significantly.

Source: Carbon Storage in Wood and Wood Products, Dovetail Partners Inc.

The Carbon Benefits of Wood Buildings

When building designers choose wood, they are reducing the carbon footprint of the structure in two important ways. Wood is the only major building material that stores carbon, thus keeping it out of the atmosphere. And using wood instead of steel or concrete means less fossil fuel consumption—and, as a result, less greenhouse gas emissions.[ii]

Increasingly, architects and engineers are utilizing life cycle assessment (LCA) as an objective way to compare the environmental impacts of their material choices. Defined under ISO 14040/14044, LCA is a scientifically-based method of evaluating products, materials, assemblies and buildings, over the course of their entire lives, using quantifiable measures of environmental impact. LCA is rewarded to some extent in the Green Globes rating system and is part of the new American National Standard based on Green Globes, *ANSI/GBI 01-2010: Green Building Protocol for Commercial Buildings*. It is currently included as a pilot credit in the LEED system, and the state of California also recently included LCA as a voluntary measure in its 2010 draft *Green Building Standards Code*.

From a carbon footprint perspective, LCA studies show that wood buildings require less energy from resource extraction through manufacturing, distribution, use and end-of-life disposal, and are responsible for far less greenhouse gas emissions, air pollution and water pollution than buildings made from other materials.[iii]

Photo: Michael Arden - Arden Photography

Avalon Anaheim Stadium[iv]

Avalon Anaheim Stadium is a luxury apartment complex in California that includes five stories of wood-frame construction over a concrete "podium" deck. Developed by AvalonBay Communities, it includes 251 apartment units, 13,000 square feet of retail and restaurant space, and two levels of subterranean parking.

Volume of wood used:
183,600 cubic feet of lumber and sheathing

U.S. and Canadian forests grow this much wood in:
15 minutes

Carbon stored in the wood:
3,970 metric tons of CO_2

Avoided greenhouse gas emissions:
8,440 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT
12,410 metric tons of CO_2

EQUIVALENT TO:

2,369 cars off the road for a year

Energy to operate a home for 1,054 years

Source: US EPA

For example, the production of steel, cement and glass requires temperatures of up to 3,500 degrees Fahrenheit, which is achieved with large amounts of fossil fuel-based energy. Wood, on the other hand, is made using energy from the sun. Manufacturing wood into products requires far less energy than other materials—and most of that comes from renewable biomass.

Biomass energy (also known as bioenergy) is electrical and thermal (or heat) energy derived from organic materials such as sawdust and other byproducts of logging, sawmilling and paper-making processes. Biomass is an abundant, clean and renewable substitute for fossil fuels such as coal and natural gas, and has long been used by the forest products industry to power its mills. On average, the U.S. and Canadian forest industries generate about 65% and 60% of their energy needs (respectively) from sources other than fossil fuels.

Photo: W.I. Bell

El Dorado High School[iv]

El Dorado High School is one of the first schools in Arkansas to make extensive use of wood following a 2009 change in state legislation that had prohibited wood in school construction. The 320,000-square-foot structure features a range of wood products, including dimensional lumber for exterior and interior load bearing walls, glulam bowstring roof trusses that span 160 feet over the basketball arena, and plywood reflectors in the auditorium to assist with acoustics.

Volume of wood used:
153,140 cubic feet of lumber, panels and engineered wood

U.S. and Canadian forests grow this much wood in:
13 minutes

Carbon stored in the wood:
3,660 metric tons of CO_2

Avoided greenhouse gas emissions:
7,780 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT
11,440 metric tons of CO_2

EQUIVALENT TO:

2,184 cars off the road for a year

Energy to operate a home for 972 years

Source: US EPA

Photo: Jerry Gregg, Hilbers Inc.

New Earth Market[iv]

The 20,000-square-foot New Earth Market in California includes a hybrid panelized roof system that offered the benefit of wood's lower cost while integrating exposed steel to achieve the modern industrial look the client wanted. The roof was designed using RISAFloor engineering software, which was recently updated to allow the design of all-wood buildings as well as hybrid structures of wood and other materials.

Volume of wood used:
2,825 cubic feet of lumber, panels and engineered wood

U.S. and Canadian forests grow this much wood in:
14 seconds

Carbon stored in the wood:
70 metric tons of CO_2

Avoided greenhouse gas emissions:
160 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT
230 metric tons of CO_2

EQUIVALENT TO:

44 cars off the road for a year

Energy to operate a home for 20 years

Source: US EPA

Adaptability and Service Life

The fact that wood buildings are easily adapted or dismantled and re-used adds to their carbon benefits. Although there are examples of wood-frame buildings that remain structurally sound after hundreds of years, studies show that North American buildings often have a service life of less than 50 years, regardless of material, because of changing needs or increasing land values.

When one considers the embodied energy in these structures and the implications of material disposal, it is easy to understand why one of the tenets of sustainable design is that buildings should last 100 years or more. However, while some people interpret this as a call for more durable materials, the foremost requirement is in fact the use of building systems that can adapt to changing needs, either through renovation or deconstruction and re-use.

North American Forests: Carbon Sinks or Sources?

Because growing forests absorb and store carbon over an extended period of time, they are generally "carbon sinks." However, if emissions exceed absorption, they also have the potential to be net carbon sources.

According to *State of the World's Forests* reports published over the last decade, the U.S. and Canada have about the same amount of forested land now as they did 100 years ago.[v] Forests in both countries have sequestered relatively high levels of carbon in recent decades; however, the amount fluctuates based on the number of wildfires and insect infestations, which cause the release of stored carbon.

Wildfire is a natural part of the forest cycle. Many Northern pine forests, for example, live between 80 and 120 years, prior to being cleansed by fire and regenerating themselves from the seeds that come from their fire-resistant cones.

Today, however, wildfires are prevented from burning unchecked because of danger to human life and property. As a result, many forests have become overly dense with excess growth and debris which, combined with more extreme weather, has caused an increase in both the number and severity of fires. The combination of older forests and changing climate is also having an impact on insects and disease, causing unprecedented outbreaks—which further adds to the fire risk.

Active forest management, which includes thinning overly dense forests to reduce the severity of wildfires, helps to ensure that forests store more carbon than they release. Forest management activities aimed at accelerating forest growth also have the potential to increase the amount of carbon absorbed from the atmosphere.

Sources

This document is based on the book, *Tackle Climate Change – Use Wood*, published in 2009 by the BC Forestry Climate Change Working Group and California Forestry Association. The book can be downloaded at *http://www.woodworks.org/woodBenefits/sustainableDesign/* and includes a complete list of sources.

End Notes

[i] *Materials Matter*, Architectural Record, March 2011, McGraw-Hill Construction, http://continuingeducation.construction.com/article.php?L=221&C=754&P=1

[ii] *A Synthesis of Research on Wood Products & Greenhouse Gas Impacts*, Sathre, R. and J. O'Connor, http://www.forintek.ca/public/pdf/Public_Information/technical_rpt/TR19%20Complete%20Pub-web.pdf

[iii] Consortium for Research on Renewable Industrial Materials, http://www.corrim.org; Athena Sustainable Materials Institute, http://www.athenasmi.org

[iv] The calculations in this document were estimated using the *Wood Carbon Calculator for Buildings*, based on research by Sarthre, R. and J. O'Connor, 2010, *A Synthesis of Research on Wood Products and Greenhouse Gas Impacts*, FPInnovations. Please note: CO_2 in all cases refers to CO_2 equivalent.

[v] *State of the World's Forest Report*, 1997-2009, United Nations Food and Agriculture Organization

Cover photo: Willson Hospice House in Atlanta, GA; Jim Roof Creative Photography

WoodWorks is an initiative of the Wood Products Council, a cooperative venture of major North American wood associations.