GREEN BUILDING AND WOOD PRODUCTS

INCREASING RECOGNITION OF WOOD'S ENVIRONMENTAL ADVANTAGES

Living Building Certification; The Bullitt Center – Seattle, Washington; Architect: The Miller Hull Partnership; *WoodWorks Multi-Story Wood Design Award, 2014.* Photo by John Stamets

Presented by: THINK WOOD™

LEARNING OBJECTIVES

After reading this article you will be able to:

1. Discuss the sustainable aspects of wood products.
2. Describe how wood contributes to credits under various green building rating systems.
3. Articulate the importance of life cycle assessment and how it can be used to evaluate the environmental performance of buildings at the design stage.
4. Describe how green building certification, sustainable forest certification, and Environmental Product Declarations complement each other to provide a more complete picture of a building's environmental performance.

CONTINUING EDUCATION

AIA CREDIT: 1 LU/HSW
GBCI CREDIT: 1 CE Hour

AIA COURSE NUMBER: ARoct2015.3
GBCI COURSE NUMBER: 920004911

Use the learning objectives above to focus your study as you read this article.

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With growing pressure to reduce the carbon footprint of the built environment, building designers are increasingly being called upon to balance functionality and cost objectives with reduced environmental impact. Wood can help to achieve that balance.

The choice to use wood as a green building material is intuitive. It's abundant, renewable and recyclable, and has a lighter carbon footprint than other construction materials.[1] Wood is also the only structural building material with third-party certification systems in place to verify that products have come from a sustainably managed resource.

In addition to its environmental benefits, wood's natural beauty and warmth have a positive effect on building occupants. In two studies conducted at FPInnovations and the University of British Columbia, for example, the use of visual wood was shown to lower sympathetic nervous system (SNS) activation, which is responsible for physiological stress responses in humans.[2] As a result, an increasing number of architects are incorporating wood in their designs as a way to achieve goals such as improved productivity and performance in schools and offices, and better patient outcomes in hospitals.[3]

With all of these attributes, wood is well positioned as a key component of environmentally superior structures. Yet, early efforts to promote green construction resulted in highly variable treatment of wood in green building rating systems—which, at the time, were largely based on long lists of prescriptive standards, typically focused on single attributes such as recycled content. Such variability can still be seen in many of the green building programs in use today. However, these systems are increasingly moving away from prescriptive standards and toward reliance on systematic, multi-attribute assessment of building products, assemblies, and completed structures through life cycle

Three Green Globes; Terrena – Northridge, California; Architect: TCA Architects; Developer: Northwestern Mutual Life Insurance Company. Photo by 360° Virtual Visions

LEED Gold; Federal Center South, Building 1202 – Seattle, Washington; Architect: ZGF Architects; *WoodWorks Commercial Wood Design Award, 2014.* All of the wood used in this project was salvaged from a 1940s-era warehouse that previously occupied the site – a total of 200,000 board feet of heavy timber and 100,000 board feet of 2x6 tongue and groove roof decking. Photo by Benjamin Benschneider

assessment (LCA). The result is greater uniformity between programs and far greater robustness in evaluation, both of which serve to leverage the environmental advantages of wood.

This continuing education course examines key green building rating programs and how wood building materials and components are rated within each. Increased reliance on LCA and environmental product declarations (EPDs), and the implications for wood construction, are also explored.

GREEN RATING SYSTEMS, CODES, AND WOOD

Of the more than 42 green building programs currently in use in the U.S. and Canada, 12 of the most prominent are examined in this article; the UK BREEAM program—the world's first comprehensive green rating system and basis for many systems worldwide—is also included.

Approaches to Rating Green Buildings

Early green building rating initiatives in North America were based on lists of prescribed measures for reducing energy consumption and various environmental impacts. Among these were Built Green, Earthcraft, Leadership in Energy and Environmental Design (LEED), and the NAHB Model Green Home Building Guidelines—precursor to the National Green Building Standard. Arranged within categories such as Energy, Water, Indoor Air Quality, Materials and Resources, and Site, prescriptive lists of recommended or required measures outlined the path toward environmentally better buildings. Each measure typically addressed a single concern or attribute such as recycled, recycled content, rapidly renewable, and sourcing. Recommendations for improving environmental performance of buildings and construction practices varied among the initiatives, as did recommendations for the use of wood and wood products.

In more recent initiatives, there has been a noticeable shift away from prescriptive measures and toward systematic, performance-based assessment using LCA. This shift is reflected in the latest version of LEED, Green Globes and several other rating systems, and is discussed later in this article.

Green Building to Code

Given broad interest in reducing the environmental impacts of buildings and their construction, it is not surprising that provisions of voluntary green building rating systems are beginning to find their way into building codes. The State of California became the first state to codify green building provisions with its *California Green Building Standards Code* (CALGreen), which applies to all occupancies within the state. Model code language has also been developed in the form of ASHRAE 189.1 and the *International Green Construction Code* (IgCC). Washington, D.C., for example, has adopted the 189.1 standard as part of its city building code, while Florida requires compliance with the IgCC in the construction of state-owned buildings. Other states and municipalities, such as Maryland, Rhode Island, Phoenix, and Scottsdale, have endorsed the use of the IgCC on a voluntary basis.

EPDs AND FOREST CERTIFICATION

The wood industry has been a leader in the development of Environmental Product Declarations (EPDs).

An EPD is a standardized, third-party-verified label that communicates the environmental performance of a product, is based on LCA, and is applicable worldwide.

An EPD includes information about both product attributes and production impacts and provides consistent and comparable information to industrial customers and end-use consumers regarding environmental impacts. The nature of EPDs also allows summation of environmental impacts along a product's supply chain—a powerful feature that greatly enhances the utility of LCA-based information.

In the case of wood products, sustainable forest management certification complements the information in an EPD, providing a more complete picture by encompassing parameters not covered in an LCA—such as biodiversity conservation, soil and water quality, and the protection of wildlife habitat.

EPDs for wood products are available from the American Wood Council (www.awc.org).

CALGreen provisions and model code language within the ASHRAE and IgCC standards are similar to those in voluntary green building rating systems. However, a comparison of all three shows greater incentive for wood use under the IgCC than CALGreen or the ASHRAE standard. For example:

- The Materials Selection section of the IgCC standard specifies that at least 55 percent of the total materials used in each building project (based on mass, volume, or cost) must be any combination of used, recycled-content, or recyclable materials, or bio-based materials, where the bio-based content is not less than 75 percent and where wood materials are environmentally certified.
- ASHRAE 189.1 contains a similar requirement, specifying that at least 45 percent of materials must be low-impact materials, with low impact defined as recycled content, regional, or bio-based materials; bio-based materials are required to comprise a minimum of 5 percent of the total cost of materials.
- CALGreen awards voluntary credits for the use of bio-based materials.

All of these initiatives emphasize use of rapidly renewable materials, defined as materials that renew in 10 years or less, rather than 11 years or more (i.e., they favor materials other than wood), although they also reward the use of certified wood. None of these programs require comprehensive environmental certification of rapidly renewable materials or of any construction material other than wood.

SUSTAINABLE FOREST CERTIFICATION

There are four primary forest certification programs operating in North America today: Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), Canadian Standards Association's Sustainable Forest Management Standards (CSA), and American Tree Farm System (ATFS). All but FSC are endorsed by the Programme for the Endorsement of Forest Certification (PEFC), an independent, non-profit umbrella organization that supports sustainable forest management globally by assessing and endorsing national forest certification standards. Certification in all cases requires third-party verification against a published, transparent standard.

Certification under these programs is separate from the green rating systems that require their use, and different also from the Environmental Product Declarations discussed in this course.

While green building programs encourage the use of certified wood products, there is no such requirement for rapidly renewable materials or products such as steel, concrete, or plastics.

LEED Certified; Biomass Heating Plant, Hotchkiss School – Lakefield, Connecticut; Architect: Centerbrook Architects and Planners
WoodWorks Green Building with Wood Design Award, 2014. Faced with the replacement of an aging fuel oil heating plant, Hotchkiss school chose to build a LEED-certified biomass facility that burns wood chips from sustainably managed forests nearby. Wood was used in the building's construction and the facility is covered with a rolling, vegetated roof that changes colors with the season. Photo by David Sundberg/Esto

NEW DEVELOPMENTS IN GREEN BUILDING RATING SYSTEMS & CODES

The following developments within major green rating systems demonstrate the shift toward LCA-based tools and data.

LEED v.4. In the Materials and Resources category of LEED v.4 (2013), optional prescriptive measures that were part of the previous version of the system—for material reuse, recycled content, and rapidly renewable materials—have been replaced with optional credits related to LCA, LCA-based environmental product declarations (EPDs), material ingredient verification, and raw material extraction (see chart below). EPDs need only be collected to gain credit; there is no requirement that they be understood or acted upon, though there is an optional credit rewarding project teams that prioritize products whose EPDs show reduced environmental impacts.

According to Dr. Jim Bowyer, director of the Responsible Materials Program at Dovetail Partners, "The two rating systems that have long incorporated systematic assessment into their programs—BREEAM and Green Globes—have more robust LCA provisions."

Changes in Materials and Resources Portion of LEED Programs – LEED 2009 to LEED v.4

LEED (2009)	LEED v.4
Building and material reuse credits (walls, floors, roof, interior elements)	Moved to Building Life Cycle Impact Reduction credit
Building life cycle impact reduction (pilot credit)	Added option for whole building LCA of structure and enclosure
	New credit, MR Credit – Building Product Disclosure and Optimization – Environmental Product Declarations focuses on selecting products with improved life cycles; rewards material optimization, disclosure, products with EPDs, and use of local products (with local now defined as a 100-mile radius)
Recycled content, rapidly renewable materials, certified wood	Moved into Building Product Disclosure and Optimization – Sourcing of Raw Materials
	New credit, Building Product Disclosure and Optimization – Sourcing of Raw Materials, rewards products from manufacturers that provide information on land use practices, extraction locations, labor practices, etc.

Green Globes v.1.3. The newest version of Green Globes (version 1.3, 2014) offers two paths to satisfying material selection requirements. One option is to conduct LCAs in the conceptual design phase of at least two building designs (core and shell including envelope), with selection of the lowest impact option. Alternatively, EPDs that comply with standards put forth by the International Organization for Standardization (ISO), third-party certifications to multi-attribute consensus-based standards, and/or third-party-certified, ISO-compliant life cycle product analyses focused on appropriate characteristics for the building system or application must comprise 10% of the selected products in order to earn credit.

BREEAM. Within the Materials section of BREEAM, credits are awarded on the basis of a building's quantified environmental life cycle impact through assessment of the main building elements—i.e., exterior walls, windows, roof, upper floors, internal walls, and floor coverings and finish. Impacts can be quantified either through use of an ISO-compliant LCA tool (wherein building designers must demonstrate that they know how to use the LCA tool and document how the building design has benefitted from its use), or through selection of building components based on either an LCA-based Green Guide developed and maintained by BRE, and/or ISO-compliant EPDs. Life cycle greenhouse gas emissions (in kilograms of carbon dioxide, or CO_2 equivalent) for each element must also be reported based on a 60-year building life.

The shift toward performance-based assessment is also reflected in ASHRAE 189.1, the IgCC, and CALGreen.

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QUIZ

1. Which of the following is not an intuitive reason to use wood as a green building material?
   a. Renewability
   b. Recyclability
   c. Carbon footprint
   d. The potential of innovative new products to achieve longer spans
   e. Ability to purchase products as third-party certified as having come from a sustainably managed resource

2. Supporting the concept that wood has a positive effect on building occupants, one study concluded that the use of visual wood:
   a. made occupants want to go outside and be in nature.
   b. elevated the heart rate of occupants, leading to stress activation.
   c. lowered occupants' sympathetic nervous system activation, which is responsible for physiological stress responses.
   d. lowered occupants' cholesterol levels, but only if they spent more than six hours a day in the room.

3. By moving away from prescriptive standards and toward reliance on systematic, multi-attribute assessment of building products, assemblies and completed structures through LCA, the result is:
   a. greater uniformity between programs.
   b. higher green building ratings.
   c. greater robustness in evaluation.
   d. a faster certification process.
   e. a and b
   f. a and c

4. Which building code(s) reference life cycle assessment as a way to achieve their environmental objectives?
   a. Green Globes
   b. *California Green Building Code* (CALGreen)
   c. *International Green Construction Code*
   d. All of the above
   e. b and c

5. In prescriptive rating systems, wood can often earn points in all but which category:
   a. siting.
   b. recycled/reused/salvaged materials.
   c. certified wood.
   d. indoor air quality.
   e. waste minimization.

6. Of the following codes and standards, which provides the greatest incentive for wood use under a Material Selection credit?
   a. *International Green Construction Code*
   b. *California Green Building Code*
   c. *International Building Code*
   d. Model Green Home Building Guidelines
   e. ASHRAE 189.1

7. Which of the following are helping to make LCA a viable option for any building designer?
   a. Low-cost or free tools that provide LCA information for generic building assemblies
   b. Environmental Product Declarations
   c. Availability of LCA experts for full building analysis
   d. All of the above

8. When comparing buildings made from different materials, LCA studies consistently confirm what attribute of wood buildings:
   a. lower cost.
   b. low embodied energy.
   c. renewability.
   d. value of carbon stored in wood products.

9. When the Athena EcoCalculator was used to evaluate three configurations of a simple building (in wood, steel and concrete) based on life cycle assessment, it found that:
   a. impacts associated with the steel design were higher in all cases than the impacts associated with the wood building.
   b. impacts associated with the concrete building were higher in all cases than the impacts associated with the wood building.
   c. each of the three hypothetical buildings had their merits and outperformed the others in at least one category.
   d. a and b

10. In an environmental context, the use of mass timber products such as CLT offers a way to:
    a. create a broader range of lower-impact structures.
    b. meet the siting requirements of green building rating systems.
    c. meet the strength requirements for LEED Platinum buildings.
    d. reduce transportation costs.

WOOD AND GREEN BUILDING RATING SYSTEMS

Generally, every prescriptive-based rating system offers a certain percentage of credits that can be achieved with the use of wood or wood products. In most cases, wood is recognized in the following areas:

Certified wood. Credits are awarded for wood that has been third-party certified as coming from a sustainably managed forest. Different rating systems allow for different certification programs, with some more inclusive than others. While rating systems commonly reward projects that use certified wood, they do not require any demonstration that competitive materials such as concrete, steel, or plastic have come from a sustainable resource.

Recycled/reused/salvaged materials. Many rating systems give credits for the use of products with recycled content. Wood products that qualify include finger-jointed studs, medium-density fiberboard, and insulation board.

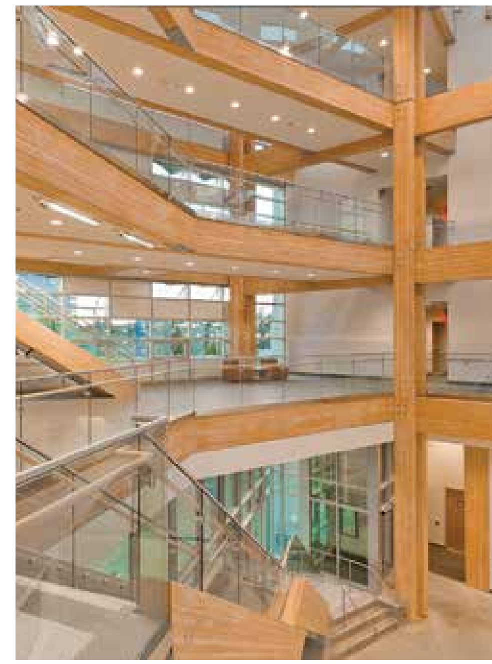
Local sourcing of materials. A number of systems place special emphasis on the use of local materials as an approach to reducing the environmental impacts of construction projects, rewarding materials sourced from within a certain radius—commonly 500 miles. However, simply tracking transportation distances ignores such critically important factors as mode of transportation and the type, efficiency, and impacts of manufacturing processes.

Helen Goodland, an expert in green building and principal of Brantwood Consulting Partnership, explains that "rather than focusing solely on transportation distances, rating systems should look at life cycle assessment methodology, which quantitatively analyzes not just transportation impacts, but the total environmental footprint of all materials and energy flows, either as input or output, over the life of a product from raw material to end-of-life disposal or reuse."

Materials efficiency. Many rating systems, such as LEED, Green Globes, Built Green Canada, BREEAM, and Earthcraft reward efficient use of building materials.

Waste minimization. Credit is often awarded for avoiding or diverting construction waste—e.g., through jobsite protocols that include pre-cut packages or off-site production of building modules.

Indoor air quality. Most rating systems have strict limits on the use of products that contain volatile organic compounds (VOCs). Many wood products are available that verifiably meet or exceed these guidelines.



Living Building Challenge; LEED Platinum (in process); Center for Interactive Research on Sustainability, University of British Columbia – Vancouver, Canada; Architect: Perkins+Will. Seeking two of North America's highest ratings, the building's moment-frame structure allows for clear-span interior spaces, while its structural deck includes 2x4s sourced from forests affected by the mountain pine beetle infestation. Photo courtesy of University of British Columbia

The ASHRAE guidelines provide alternative prescriptive and performance pathways. The performance option requires that LCAs be conducted for a minimum of two building design alternatives. Assessment must demonstrate at least a 5 percent improvement in at least two categories, including land use (or habitat alteration), resource use, climate change, ozone depletion potential, human health effects, ecotoxicity, eutrophication, acidification, or smog. Completion of an LCA eliminates the need to adhere to prescriptive low-impact material requirements outlined earlier.

Similarly, the IgCC guidelines also offer the option to pursue either a prescriptive or performance path. Here, choice of the performance pathway requires a whole building LCA and demonstration that a given project achieves not less than a 20 percent improvement in environmental performance as compared to a reference design of similar usable floor area, function, and configuration that meets the minimum energy requirements of IgCC and structural requirements of the *International Building Code*. Environmental performance improvement is required in global warming potential and at least two of the following impact measures: primary energy use, acidification potential, eutrophication potential, ozone depletion potential, and smog potential. As in the ASHRAE program, fulfillment of this requirement eliminates the need to document adherence to a number of prescriptive elements related to material selection. CALGreen contains a similar provision.

LIFE CYCLE ASSESSMENT: GETTING TO A MATERIAL'S REAL GREEN QUOTIENT

Life cycle assessment is sometimes described as mysterious and complicated. Yet, what is involved is simply a thorough accounting of resource consumption, including energy, and emissions and wastes associated with production and use of a product. For a "product" as complex as a building, this means tracking and adding up inputs and outputs for all assemblies and subassemblies—every framing member, panel, fastener, finish material, coating, and so on. Further, to ensure that results and data developed by different LCA practitioners and in different countries are comparable (i.e., that results allow apple-to-apple comparisons), LCA practitioners must strictly adhere to a set of international guidelines set forth by the International Organization for Standardization.

Tracking products and co-products through a supply chain and properly allocating resource use, emissions, and wastes to various outputs can indeed be complicated and expensive. However, a growing number of LCA tools have made LCA a viable option for any designer. User-friendly, low-cost (in most cases free) tools, such as the Athena Impact Estimator for Buildings (IE), provide life cycle impact information for an extensive range of generic building assemblies, or designers can choose to undertake full building analyses. LCA-based data is also available in the form of standardized, easy-to-understand EPDs for a wide range of products.

The wood industry has been an early adopter of EPDs, undertaking research and developing life cycle information that verifies the environmental impact of wood building products. EPDs on wood products are available from the American Wood Council (www.awc.org) along with transparency briefs summarizing the most critical data presented in each. (For more information on EPDs, see the continuing education course *Wood and Environmental Product Declarations*.[4])

Increased use of LCA in the evaluation of building design alternatives and material selection greatly favors wood in all types of construction, since environmental impacts across a large spectrum of indicators tend to be significantly lower for wood products than alternative materials.[5] Scientific comparisons of functionally equivalent buildings, components, and subassemblies have been remarkably consistent in this regard, with wood almost invariably found to be the low-impact option.

COMPARISON OF ENVIRONMENTAL IMPACTS OF STEEL VS. WOOD DESIGN (Values indicate magnitude of impact associated with steel design as multiple of wood design impact)							
Fossil Fuel Consumption	Weighted Resource Use	Global Warming Potential	Acidification Potential	Human Health Respiratory Effects Potential	Eutrophication Potential	Ozone Depletion Potential	Smog Potential
1.4x	1.02x	1.6x	1.4x	1.3x	3.0x	1.5x	1.2x

COMPARISON OF ENVIRONMENTAL IMPACTS OF CONCRETE VS. WOOD DESIGN (Values indicate magnitude of impact associated with concrete design as multiple of wood design impact)							
Fossil Fuel Consumption	Weighted Resource Use	Global Warming Potential	Acidification Potential	Human Health Respiratory Effects Potential	Eutrophication Potential	Ozone Depletion Potential	Smog Potential
1.9x	2.3x	3.0x	2.4x	2.1x	4.7x	5.8x	2.4x

Source: Athena EcoCalculator

SYSTEMS EXAMINED IN THIS ARTICLE

BREEAM® – The UK-based Building Research Establishment's (BRE) Environmental Assessment Method has rating systems for ten different building types. Within each, assessment of performance occurs within ten categories. Scores across all categories are added together to produce a single overall score that, along with evidence of compliance with specific requirements, determines the overall project rating. Established in 1990, BREEAM is one of the world's most widely used green building rating systems; 425,000 buildings currently have certified BREEAM assessment ratings and two million have registered for assessment.

LEED® (Leadership in Energy & Environmental Design) – This building rating and certification program was developed by the U.S. Green Building Council (USGBC) and provides third-party verification that a building or community was designed and built in accordance with specified practices and performance measures within eight categories. Adherence to required elements and numerical scores across all categories is used in determining an overall project rating. Established in 2000, LEED has been used to certify more than 2.8 billion ft^2 of building space globally. The newest version (v.4) was released in 2013. LEED Canada operates independently from the USGBC, and is governed and operated by the Canadian Green Building Council.

Green Globes™ – This rating system began in Canada as an offshoot of BREEAM. The Green Building Initiative (GBI) acquired the rights to distribute Green Globes in the United States in 2004, and in 2005 became the first green building organization accredited as a standards developer by the American National Standards Institute (ANSI). The Green Globes program encompasses new construction and continuous improvement in office buildings, multifamily structures, hospitals, and institutional buildings. A web-based tool allows self-assessment of building projects, with third-party on-site inspection required for certification. Green Globes is one of two rating systems approved by the U.S. government for accreditation of federal building projects. In Canada, it is the basis for the Building Owners and Managers Association of Canada's (BOMA) "BESt" rating system for existing commercial buildings.

Built Green™ – This voluntary program for residential construction was developed in the mid-1990s by home builders in Colorado and by home builders and government in Washington. Individual programs are administered by local home builder associations. Using a checklist-based system, Built Green offers certification of single and multifamily residences, with the highest levels of certification typically requiring third-party verification. In Canada, Built Green is owned and managed by the Built Green Society of Canada. There, the system is open to members of participating home builder associations and certification is available for new single-family homes and row homes, high density housing, and renovation projects. A communities program is under development.

EarthCraft™ – Established in 1999 by the Greater Atlanta Home Builders Association and Southface, EarthCraft is a green building certification program serving Georgia, Virginia, Tennessee, Alabama, North Carolina, and South Carolina. The rating system encompasses single-family homes, multifamily structures, renovation projects, community developments and light-commercial buildings. To date, more than 25,000 homes, multifamily units and commercial buildings have been certified. Provisions within this standard are similar to those in LEED 2009.

National Green Building Standard® – In 2007, the National Association of Home Builders (NAHB) and International Code Council (ICC) joined forces to establish an environmental standard for residential construction. The result was a voluntary standard that includes single and multifamily homes, residential remodeling and site development projects. Based on earlier-developed NAHB Model Green Home Building Guidelines, the standard gained ANSI approval as ICC-700 in early 2009. The recently released *International Green Construction Code*, a model code, requires compliance with ICC-700 if a jurisdiction chooses to regulate residential buildings four stories or less in height.

Earth Advantage® – The Earth Advantage program is administered by the Earth Advantage Institute, an organization that began in 2000 as an energy-efficiency program of Pacific Gas and Electric. In 2005 it became an independent non-profit entity. The Institute provides training, research, and certification services to building professionals across the U.S. Residential certification programs include net zero, new home, multifamily and remodel. A commercial certification program focuses on buildings of less than 50,000 ft^2, but accommodates buildings up to 100,000 ft^2. The standards reference the ASHRAE 90.1 energy code and additional standards and tools including Forest Stewardship Council, GreenGuard®, and Green Seal.

Living Building Challenge – This program of the Cascadia Green Building Council (a chapter of both the USGBC and Canadian Green Building Council) was developed in 2006. Now administered by the International Living Building Institute, it is meant to be the next step after LEED Platinum and a step before regenerative buildings. It is intended "to define the highest measure of sustainability attainable in the built environment based on the best current thinking—recognizing that 'true sustainability' is not yet possible." As of April 2015, eight projects have achieved full certification, and 12 others have achieved net zero energy building certification.

CALGreen – The *California Green Building Standards Code* is a part of the California Building Code and applies, with few exceptions, to all occupancies in the state. Put into effect in 2011, it is the first statewide green building code. To meet code requirements, projects must satisfy mandatory elements, exceed California Energy Code requirements, and comply with a certain number of provisions on a voluntary measures list. Local jurisdictions are allowed to establish more restrictive standards.

IgCC – The *International Green Construction Code* is not a green rating system, but a model code intended to promote safe and sustainable construction in an integrated fashion with the ICC family of codes, including provisions of the *International Energy Conservation Code* and ICC-700. ASHRAE Standard 189.1 is also incorporated as an alternate path to compliance. The IgCC was published in 2012 after three years of development and consultation. The document provides model code language to states and municipalities that wish to establish a regulatory framework specific to green commercial construction and remodeling. Code language establishes minimum regulations for building systems and site considerations through both prescriptive and performance-related provisions.

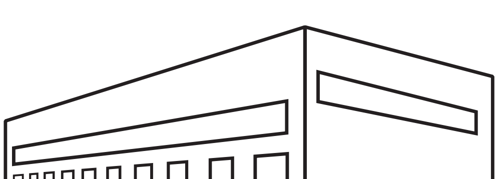
ASHRAE Standard 189.1 – An ANSI standard written in model code language, ASHRAE 189.1 provides minimum requirements for high-performance green buildings, and applies to construction of all new and remodeled commercial buildings. Developed jointly by ASHRAE, the USGBC, and the Illuminating Engineering Society, it serves as a compliance option in the 2012 IgCC.

As an example of the environmental performance of wood structures in comparison to those constructed of other materials, a highly regarded and commonly used LCA tool, the Athena EcoCalculator, was used to evaluate three alternative configurations of a simple building. Designed for the Atlanta geographical area, the building footprint was 20,000 ft^2 (100 ft x 200 ft). Two stories in height, the structure was 20 feet tall with 40,000 ft^2 of total floor area. To simplify analysis and comparison of materials in particular, the theoretical building was analyzed without windows, doors, or internal partitions. Of the three configurations, one was wood, one steel, and one concrete. All were assumed built on a concrete foundation and slab.

This analysis involved systematic assessment using life cycle methodology of all building assemblies beginning with raw material extraction through primary and secondary manufacturing, transport at all stages of the production chain and to the job site, and building construction. Differences among the wood, steel, and concrete structures are shown in the table on the previous page.

Impacts associated with the steel design as compared to the wood design are mostly 1.3 to 1.6 times greater, with a range of 1.02 to 3.0 times. Lower impacts are indicated for the wood design in every impact category. Comparison of the concrete vs. wood design shows even greater differences. In this case, environmental impacts associated with the concrete design range from 1.9 to 5.8 times greater than for the wood design. Again, impacts across all indicators are lower for the wood design. The impact categories in the tables closely match those specified in rating tools and code language where use of LCA is encouraged or rewarded.

One reality consistently revealed by LCA is the low embodied energy in wood structures compared to those built of steel or concrete.[6] The term 'embodied energy' refers to the total consumption of energy linked to production of a building, including resource extraction,



TWO STORIES; 200' x 100' x 20' height; 20,000 ft^2 footprint
Total ft^2 = 40,000

LEED Platinum; James and Anne Robinson Nature Center – Columbia, Maryland; Architect: GWWO, Inc./Architects; *WoodWorks Institutional Wood Design Award, 2014.* Photo by Robert Creamer Photography

manufacturing, transport, and installation of building materials. According to Dr. Bowyer, "The embodied energy of wood assemblies has consistently been found to be 20 to 70 percent lower than functionally equivalent steel or concrete assemblies."

Comparison of the environmental impact measures linked to material selection obtained through LCA (tables on the previous page) and material selection factors typically considered in prescriptive-based rating systems reveals a startling reality. Unless they include LCA, none of the prescriptive-based rating systems reward superior performance, or even consider in building material selection, such things as fossil fuel consumption, global warming potential, total resource use, non-renewable resource consumption, acidification or eutrophication potential, ozone depletion, smog potential, or water use. The reason is that any rating system that does not incorporate LCA or LCA-based tools and information *does not have the capacity* to consider these things. The same is true of prescriptive pathways within systems that do incorporate LCA and LCA-based tools and information, but do not require their use.

WOOD AND CARBON

Although LCA recognizes products associated with low CO_2 emissions, long-term carbon storage is not one of the metrics measured. Wood performs well on both counts—but its benefits are most evident when the forest/wood cycle is viewed as a whole.

In the process of photosynthesis, trees absorb carbon dioxide from the atmosphere, release the oxygen and incorporate the carbon into their trunks, branches, leaves and root systems. Trees that decompose and die in the forest release this carbon back into the atmosphere slowly, and it is released more quickly in forests that succumb to insects, disease or wildfire. However, if the trees are harvested and manufactured into lumber and other forest products, these products continue to store carbon while the forest regenerates and once again begins absorbing CO_2. In the case of buildings, this carbon is stored for the lifetime of the structure—or longer, since wood also lends itself to adaptation, salvage and re-use. Wood can also be used as a low-carbon substitute for fossil energy.

The second aspect to wood's relatively light carbon footprint is that it grows naturally and requires comparatively little additional energy to manufacture into products. This gives wood an environmental advantage over construction materials such as steel, cement and glass, the production of which requires temperatures of up to 3,500° F and large quantities of energy,

Carbon Benefits: Crescent Terminus – Atlanta, Georgia; Architect: Lord Aeck Sargent. According to the Wood Carbon Calculator for Buildings (www.woodworks.org), Crescent Terminus has a carbon benefit equivalent to 2,583 cars off the road for a year or the energy to operate a home for 1,149 years. Photo by Richard Lubrant

Crescent Terminus
Atlanta, GA

Volume of wood:
3.1 million board feet (equivalent)

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

Carbon stored in the wood:
4,327 metric tons of CO_2

Avoided greenhouse gas emissions:
9,196 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
13,523 metric tons of CO_2

EQUIVALENT TO:

2,583 cars off the road for a year

Energy to operate a home for 1,149 years

Source: US EPA

Estimated by the Wood Carbon Calculator for Buildings, based on research by Sathre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent.

resulting in substantial greenhouse gas emissions.[7]

Taking advantage of wood's carbon and other environmental benefits in building construction comes with a bonus—namely that, in many cases, wood construction is less expensive than other building solutions. For example, one high school in Arkansas documented in a case study saved $2.7 million by changing the design of its new school from steel and masonry to wood—while achieving a carbon benefit of 11,440 metric tons of CO_2.[8]

NEW MATERIALS CREATE NEW POSSIBILITIES

The emergence of mass timber products such as cross laminated timber (CLT) is allowing designers to create a broader range of lower-impact structures. Internationally, for example, CLT's relatively light carbon footprint is helping to drive a trend toward taller buildings, such as the eight-story Bridport House in the United Kingdom and the 10-story Forté in Australia.

Although relatively new in North America, CLT has been used in a variety of building designs, from the LEED Gold-certified Earth Sciences Building at the University of British Columbia to the new Fort McMurray Airport, where designers have taken a "first principles" approach to sustainability, blending best practice with the monitoring approaches of various green building rating systems. In the U.S., examples include the *The Crossroads*, a 52,000-square-foot staff and visitor facility at the LEED Gold-certified Promega Feynman Center in Wisconsin, and a two-story school in West Virginia.

WHAT THE FUTURE HOLDS

With growing concerns over climate change and the environmental impact of buildings, it stands to reason that green building concepts will be increasingly incorporated into structures of all kinds. What began as an interest in reducing energy consumption to save money in the 1970s has led to today's net zero energy objectives, and net zero carbon is another frontier. With attention turning away from the prescriptive approach to sustainable design and toward LCA-based tools that identify the lowest impact alternatives, more designers will become familiar with the environmental advantages of wood, and wood products will be a building material of choice for a growing range of applications.

For more information on the themes described in this article, download the *Green Building with Wood Toolkit* at thinkwood.com. ■

ENDNOTES

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