The Role of Wood Products in Green Building

Presented By: THINK WOOD®

Oregon Conservation Center | Photo Courtesy: Jeffrey Roscoe

LEARNING OBJECTIVES

1. Understand the role wood products play in sustainable building design and construction.
2. Describe common green building standards, certification and ratings programs and identify some of their similarities and differences.
3. Recognize terms used for green building and understand how things like forest certification, EPDs and LCAs can be used to meet green building standards.
4. Discuss green building trends regarding building codes, building types and procurement policies.

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UNDERSTANDING HOW WOOD USE MEETS SUSTAINABLE BUILDING OBJECTIVES

The complex process of building design and construction must meet many criteria—aesthetics, safety, budget, code compliance, occupant comfort, durability and more. Architects and other design professionals are increasingly recognizing the value of adding green building to the list.[1]

This course will help you understand that sustainable design begins with sustainable building materials. Because there are many factors to consider in assessing a building's sustainability, it can be challenging to fully understand the long-term impacts of choosing one building material over another. However, material choice greatly affects the environmental impact of buildings, both during construction and over the building's lifecycle.

Because 80 percent of a building's embodied carbon comes from the structural materials used to build it, building material specification is impactful.[2] 'Upfront' embodied carbon is the total amount of greenhouse gas emissions associated with the harvesting/extraction, transportation and manufacturing, of materials used in building construction. The effects of sustainable building design extend well beyond the construction phase to the way a building performs over its lifetime—through lower energy use (operation carbon) and occupant health and well-being, for example.

Architects can incorporate sustainable features into their designs through their choice of building materials. Wood building products and components fit well within many sustainable building scenarios, while also adding other benefits such as natural warmth and beauty. Wood is a versatile, durable building material that can be used in almost any building application. It is renewable and sustainable, and wood products typically require less energy to produce than other building materials.[3] Green building standards also recognize wood's contribution to improved energy performance over time.

THE BASICS OF GREEN BUILDING

The world's ability to meet climate goals depends on reducing carbon emissions, and the building industry accounts for nearly 40 percent of annual global CO_2 emissions.[4] Architects and designers are showing that buildings can be constructed sustainably, with a reduced carbon footprint, while still meeting critical design goals including functionality, cost, comfort and more.

While there are many ways to approach it, the goal of green building is to design

projects and use construction processes that are environmentally responsible and resource-efficient, to reduce carbon emissions both during construction and throughout a building's lifecycle. This can be accomplished a number of ways, from smart site selection and construction material choice to how the design and building materials impact energy use over the life of the building.

A 2018 study from the World Green Building Council found that additional costs of green building can be outweighed by the lifecycle benefits of creating a better building, which include lower energy consumption, improved occupant satisfaction and well-being, and better financial performance in terms of improved lease rates and developer return on investment.[5] The 71 global companies who participated in the study found reduced staff turnover and absenteeism along with improved productivity and job satisfaction—all of which translate to measurable economic benefits.

TOOLS USED TO ASSESS GREEN BUILDING CERTIFICATION

There are as many reasons to pursue green building certification as there are certification programs from which to choose. Certification can be used to comply with client, civic or jurisdictional requirements; it can also serve as a marketing tool for the building owner to help attract tenants.

To understand green building certification, it is important to become familiar with the tools that are primarily used to assess certification requirements

Life Cycle Assessment (LCA)

An LCA is a performance-based methodology that measures the environmental impact of a product, assembly or structure over its lifespan; it's a way to assess the sustainability of a building and its constituent parts. LCA measures the energy required to both construct and operate a product or building over its lifetime, beginning with the extraction or harvest of the material through to its manufacture, distribution, installation, use and end-of-life disposal.

LCA analysis is required for many green building certification programs; results allow project teams to understand the overall impact of choosing one building product or construction system over another. LCA studies consistently show that wood products have lower environmental impact than alternative materials. The Consortium for Research on Renewable Industrial Materials (CORRIM) has done numerous LCA studies comparing wood products to other building materials, and has found that wood has lower carbon emissions and uses less overall energy to produce than other products.[6]

There are numerous LCA options available to help guide design decisions by evaluating the environmental impact of everything from individual building products to entire buildings, known as WBLCA (Whole Building Life Cycle Assessment).

LCAs provide varying levels of detail and complexity:

- Athena EcoCalculator is a free tool that measures the LCA of common building assemblies. Data is pulled from a library of predefined options for quick and simple assessments. Separate calculators are available for commercial and residential assemblies, and calculations are based on an assumed building service life of 60 years.
- Athena Environmental Impact Estimator is a more robust tool that evaluates whole building LCAs; it also measures the environmental impacts of the building's ongoing operation, allowing for easy comparison of design options. This tool can be used for new construction, renovations and additions on all building types.
- The Embodied Carbon in Construction Calculator (EC3) is a database populated with product EPDs. It is useful after a building has been designed. SimaPro and GaBi Solutions are life cycle inventory databases that also have tools to conduct an LCA and and measure the environmental impact of individual building products.
- Tally, a Revit software plug-in, uses the GaBi database to evaluate WBLCA.
- One-Click is another LCA tool that can be used for early design optimization, lifecycle costing, and benchmarking to similar projects and other metrics.

GREEN BUILDING TERMINOLOGY

People use many terms when describing green building, and it's important to understand what they mean in a design and build context.

- **Carbon footprint:** Includes both the embodied carbon and the operational carbon of a building.
- **Carbon sequestration:** Carbon can be captured and stored in a material over time, reducing the amount of carbon dioxide that material releases into the atmosphere. Because trees absorb and store carbon dioxide from the atmosphere, they can be considered a carbon sink.
- **Carbon sink:** Something that absorbs more carbon than it releases. A healthy, growing forest is an example of a carbon sink.
- **Cradle-to-Gate:** Life cycle stages from harvesting/extraction to the factory gate, before it is transported to the jobsite.
- **Cradle-to-Grave:** All life cycle stages from harvesting/extraction through end-of-life, including landfilling.
- **Embodied carbon:** Carbon dioxide equivalent ($kgCO_2eq$) emissions from the declared life cycle stages. It can be measured from cradle-to-gate, and cradle-to-grave (end of its use).
- **Green building:** High-performance building approach that uses environmentally responsible and resource efficient building practices to reduce a building's carbon impact throughout its life.
- **Life Cycle Assessment (LCA):** Evaluates the environmental impacts of a product or building throughout declared life cycle stages. It may include both operational and embodied carbon emissions.
- **Operational carbon:** Carbon emissions created by using energy to power, heat or cool a building.
- **Volatile Organic Compound (VOC):** A carbon-based compound that can easily evaporate and become gaseous under normal atmospheric conditions. VOCs are emitted by thousands of products, and can contribute to poor air quality.
- **Whole Building Life Cycle Assessment (WBLCA):** An LCA that covers all stages in the life cycle of a building and its components, from raw material extraction (cradle) to product manufacturing, transportation, building construction and operation and eventual recycling or disposal (grave).

LCA TOOLS AND CARBON CALCULATORS

		Emissions Considered		Acceptability for Green Building Credits	
		Em bodied Carbon	Operational Carbon	LEED v4.1	Green Globes
Athena Impact Estimator for Buildings	Detailed, robust WBLCA	Yes	Yes	Yes	Yes
Tally	Detailed, robust WBLCA; can be integrated with Revit	Yes	Yes	Yes	Yes
One-Click LCA	WBLCA with regionalized generic data and global EPD library	Yes	Yes	Yes	Yes
Athena EcoCalculator	Simplified LCA for evaluating common building assemblies	Yes	Yes	Yes	Yes
Embodied Carbon in Construction (EC3/ Beta Version)	EPD database, sortable by embodied carbon enabling product comparisons; can	Yes	No	Pilot credit	No
WoodWorks Carbon Estimator	Carbon	Yes	No	No	No
WoodWorks Carbon Calculator	Detailed estimate based on wood products used (wood structures only)	Yes	No	No	No

Source: WoodWorks

Forest Certification

Forest certification programs help ensure that a forest landowner is following sustainable forest management practices including harvest methods and replanting. There are several programs used in North American forest management:

- American Tree Farm System (ATFS)
- Canadian Standards Association (CSA)
- Forest Stewardship Council (FSC)
- Sustainable Forestry Initiative (SFI)

For each, a third-party certifier evaluates the forest management practices being followed by landowners and foresters against the organization's requirements. While all have the same basic mission– to provide guidelines that support sustainable forest management—there are differences in the requirements of how each program is structured.

It is important to recognize that forests are not required to be certified. Some private and public landowners follow sustainable forest management practices but choose not to pay for certification. In contrast, some lands are certified by multiple programs. As of 2017, nearly 100 million acres of U.S. forested land were certified; about 15 percent was certified by more than one program. Canada had more than 430 million acres of certified forests, about 10 percent was double certified.7

U.S. federal timberlands are not certified but this does not mean they are not being sustainably managed. In 2007, the Pinchot Institute conducted a study of five national forests and found their management practices met many of the certification requirements in terms of forest planning, protection of threatened and endangered species and others.[8]

Many state regulations meet or exceed forest certification requirements. For example, all forestlands and conservation areas managed by the Washington State Department of Natural Resources (2.4 million acres) are certified under the SFI program. About 176,000 acres of those forestlands are also certified under the FSC U.S. Forest Management Standard.[9] In 2016, nearly 5 million acres of Oregon timberlands were certified by ATFS, FSC or SFI.[10]

While several green building standards have required use of wood from certified forests in the past, many are also now recognizing wood harvested from what is known as legal or responsible product source categories. A Responsible source is defined as a forest site that is replanted after harvest by trained loggers, where endangered species are protected and best management practices are followed. Once the Responsible source is established and verified, its products must be delivered through a chain-of-custody (CoC) that can be used to obtain credit under the green building standard. CoC documentation verifies the source of the timber as it moves from forest to construction site.

Leadership in Energy and Environmental Design (LEED), one of the most well-known green building certification programs, requires that wood products be from certified forests. However, LEED v4.1 has a Pilot Alternative Compliance Path, allowing wood products sourced from ASTM D7612-certified forests to earn LEED credit if they are all from legal (non-controversial) sources such as forests managed using responsible practices and if at least 70 percent (based on cost) are from responsible sources.[11]

Environmental Product Declarations (EPDs)

While forest certification verifies that a forest is being managed sustainably, an EPD is a way to verify the environmental impact of a specific product. EPDs allow architects to evaluate a product's lifetime environmental impact in terms of embodied energy, carbon emissions and waste generation as well as for other factors such as global warming and ozone depletion. When considered alongside other factors such as recycled content or VOC emissions, EPDs help architects make informed building material choices.

The International EPD System is a global program for environmental declarations based on ISO 14025 (*Environmental Labels and Declarations*) and the European standard EN 15804 (*Sustainability of Construction Works - Environmental Product Declarations - Core Rules for the Product Category of Construction Products*).[12] Wood EPDs are third-party verified by UL Environment, an independent certifier of the sustainable attributes of various products. EPDs for

softwood lumber and plywood, oriented strand board (OSB), glue-laminated beams (glulam), laminated veneer lumber (LVL), wood I-joists, laminated strand lumber (LSL) and other wood building products are published by the American Wood Council.[13]

Wood EPDs take a 'cradle-to-gate' approach, measuring environmental impact from raw material harvest through manufacturing to the point when the product is ready to ship from the manufacturing facility. Since wood products are manufactured all across North America, and since they are used in many applications, it is difficult to make assumptions about their end-use environmental impact, which makes 'cradle-to-grave' or 'cradle-to-cradle' measurements difficult to obtain.

EPDs are becoming increasingly important in building design and construction. Products with verified EPDs can receive credit through LEED v4.1, Green Globes and other green building rating systems. EPDs can also be used to show compliance with International Green Construction Code (IgCC) and other green building codes. In fact, the 2018 IgCC requires that at least 10 materials installed in a building have an EPD.

GREEN BUILDING RATING SYSTEMS

There are many reasons a building owner chooses to seek green building certification for their project. Some state and local governments have made certification a requirement to meet energy efficiency goals. Some certified buildings may qualify for tax-related incentives. Additionally, developers are finding that a growing number of commercial and residential tenants have their own sustainability goals or commitments, which factor into their choice to live or work in a certified green building. At the same time, some building owners require that their project be designed to follow green building standards, but they don't apply or pay for certification.

Regardless of the reason, architects have numerous building standards, certifications and rating systems available to help guide them toward sustainable design principles. Virtually all of them emphasize efficient use of building material resources, as well as energy and water use, indoor air quality and other factors.

CASE STUDY: THE ALLIANCE FOR SUSTAINABLE COLORADO

Photo courtesy: Gensler | Photo: David Lauer Photography

Location: Denver, CO; Architect: Gensler

Since re-use is considered by some to be the ultimate sustainable building approach, this renovation of a six-story warehouse qualified for LEED v4 Platinum certification and won a long list of green building awards, including the National Leadership Award from the U.S. Green Building Council. The renovation reconfigured a 1908 building to create collaborative, shared workspaces and conference rooms. Since the building is home to an organization whose goal is to promote sustainability, the design team took full advantage of the existing wood structural members while adding features to reduce energy use. The design left the original heavy timber beams exposed and incorporated other natural wood elements to reinforce wood's biophilic benefits, promoting health and wellness in the workplace.

There are many well-known national green building certification programs, including:

- Leadership in Energy and Environmental Design (LEED)
- Green Globes
- National Green Building Standard (NGBS)
- Living Building Challenge, Energy Star, BREEAM (Building Research Establishment Environmental Assessment Method) and others

The environmental advantages of using wood products are recognized by each certification system, but each program varies in how wood use is credited. With two of the most well-known programs, LEED v4 and Green Globes v1.4, it is possible to earn 8-10 percent of potential credits through substantial use of wood in construction.[14]

Green building rating systems also assign credits based on the use of LCA tools, renewability of the resource, EPD availability, forest certification, locally produced materials, third-party certification, ability for materials to be recycled and more.

LEED

LEED is one of the most well-known green building rating systems. Operated by the U.S. Green Building Council (USGBC), the most current version is LEED v4.1. LEED's Building Design + Construction rating system can

be used to certify new construction and major renovation projects for many building types including mixed-use, retail, hospitality, education, and healthcare.

LEED gives designers the ability to earn points for a project by taking design measures that are deemed to positively impact the environment, like using sustainable materials or making efficient use of resources. The number of points earned allows a project to be designated in one of four ways: Certified, Silver, Gold or Platinum—with Platinum being the highest level. The Alliance for Sustainable Colorado, a renovation project in Denver, Colorado, qualified for LEED v4 Platinum certification, in part due to its reuse of the existing wood structural members.

LEED v4.1 uses many of the tools described above, including WBLCA, which allows for a whole building comparison of the environmental impacts of various structural materials. It also recognizes products that have a qualified EPD conforming to ISO 14025 (*Environmental Labels and Declarations*) and ISO 21930 (*Sustainability in Buildings and Civil Engineering Works*).[15 16]

Use of wood as a building material is covered in the Materials and Resources Chapter of LEED v4.1 in the Building Design and Construction (BD+C) category; credits recognize wood's favorable environmental attributes such as certification, recycled content in engineered wood products and wood that is manufactured and/or harvested within a 500-mile radius of the project.

Building designers can use the LEED credit library to determine which points can be earned for using wood. For example, using the Alternative Compliance Path in LEED v4.1, Responsible Sourcing of Raw Materials provides 1 to 2 points, rewarding project teams for selecting products verified to have been sourced responsibly. To achieve a LEED point under this criterion, the user must know that:

- 100 percent of the wood used is from Legal (non-controversial) sources, and
- 70 percent is from Responsible sources

Once the above two criteria are satisfied, then chain-of-custody (CoC) certification can satisfy the final requirement that at least 25 percent (based on cost) of all permanently installed building materials (such as structural wood framing) meet the Responsible Extraction Criteria. Wood products sourced from Certified sources as defined by ASTM D7612-10 (2015) satisfy the requirements of this credit.

USGBC RECOGNIZES ALL CERTIFICATION STANDARDS FOR LEED POINTS

PROGRAM NAME	Legal (non-controversial) Compliant?	Responsible Sources Compliant?	Certified Sources Compliant? (CoC)
Sustainable Forestry Initiative (SFI)			
• Forest Management (via SFI CoC certificate)	Yes	Yes	Yes
• SFI Fiber Sourcing certificate	Yes	Yes	No
American Tree Farm System (ATFS)			
• Forest Management (via SFI CoC certificate)	Yes	Yes	Yes
Canadian Standards Association (CSA)			
• Forest Management (via SFI CoC certificate)	Yes	Yes	Yes
Programme for the Endorsement of Forest Certification (PEFC)			
• Forest Management (via PEFC chain of custody certificate)	Yes	Yes	Yes
• PEFC Due Diligence System	Yes	No	No
Forest Stewardship Council (FSC)			
• Forest Management (via FSC chain of custody certificate)	Yes	Yes	Yes
• FSC Controlled Wood certificate	Yes	No	No

https://www.sfiprogram.org/wp-content/uploads/LEED_ACP_April2016_Final.pdf

Green Globes

This green building assessment and certification program from the Green Building Initiative (GBI) generates a building score based on a 1000-point-based rating system. Green Globe certification recognizes responsible material selection as well as efforts to conserve energy and reduce water consumption over time. The assessment is verified by a third party, then awarded a rating based on accumulated points—either One, Two, Three or Four Green Globes.

Like LEED, Green Globes have several qualification categories: new construction, existing buildings, core & shell, sustainable interiors plus multi-family new construction and existing buildings. The certification process evaluates multiple assessment areas, including project management, site, energy, water, materials and resources, emissions and indoor environment. An architect's choice of wood for structure and finish falls under the Materials and Resources category.

Specifying wood can help project teams achieve higher scores in their Green Globes assessment, with points related to energy and acoustic properties, renewability, and economic value, both to the project itself and to the communities who manufacture the wood products.

Projects can earn points for the use of certified wood products including SFI, FSC, ATFS and CSA. Points can also be earned for using traditional lumber framing, mass timber and engineered wood products. Construction methodologies, like prefabricated components, also qualify for Green Globes points, due to reduced construction waste.

National Green Building Standard

While many architects think of the National Green Building Standard (NGBS) as limited to single-family homes, this green building certification program covers multi-family construction as well. The goal of NGBS is to help architects build beyond existing code, to design buildings that are sustainable and cost-effective.

Approved by the American National Standards Institute (ANSI), the NGBS is a points-based system with four certification levels—Bronze, Silver, Gold and Emerald. The

GREEN BUILDING RATING AND CERTIFICATION SYSTEMS

Name	Version	Certifications	Building Types	Wood Relevance
LEED *Leadership in Energy and Environmental Design* U.S. Green Building Council	LEED v4.1	Certified Silver Gold Platinum	Commercial: all Industrial: all Mixed use: all Residential: all	Rewards use of sustainable materials, wood can be sourced from any certified forests (SFI, FSC, ATFS, CSA and Programme for the Endorsement of Forest Certification (PEFC)), recognizes products with EPDs, accepts whole building LCA Awards credits for LCA, EPD procurement, and reuse of existing buildings and materials
Green Globes Green Building Initiative		One Green Globe Two Green Globes Three Green Globes Four Green Globes	Commercial: all Mixed use: all Residential: multi-family only	Requires third-party review with onsite walk-through. Recognizes all forest certification programs (SFI, FSC, ATFS, CSA and PEFC). Credits for the use of bio-based materials and waste reduction.
National Green Building Standard Home Innovation Research Labs	ICC/ASHRAE 700-2015	Bronze Silver Gold Emerald	Residential: all, including single- and multi-family	Credits use of wood and recyclable construction materials. Requires inspection by third-party verifiers during framing and upon completion.

most current version is the ICC 700-2020 NGBS. Wood use earns points in several categories, including resource efficiency, energy efficiency and indoor environmental quality. In fact, several wood products manufacturers have specific NGBS-certified products available.[17] NGBS compliance is verified by third-party inspectors overseen by Home Innovation Research Labs.

BUILDING SUSTAINABLY USING WOOD

When designing to meet green buildings standards, wood adds value on a number of levels. Wood is the only major building material that is renewable. As trees grow, they release oxygen and absorb CO_2. And when those trees are harvested, the carbon is sequestered, held in the wood for as long as the wood remains in use.

When wood is used for the structure of a building, it reduces the carbon footprint in two ways—through carbon storage and through avoided greenhouse gas emissions, since wood products use less energy from fossil fuels in their manufacture than other materials. In fact, wood products comprise 47 percent of the industrial raw material manufactured in the U.S., yet consume only 4 percent of the energy needed for production.[18] Every ton of wood used in place of an alternative building material potentially avoids 2.1 tons of carbon, or 7.7 tons of carbon dioxide equivalent (CO_2e).[19]

HOW MUCH CARBON ARE WE TALKING ABOUT?

The WoodWorks Carbon Estimator and Carbon Calculator use project wood volume to estimate the total wood mass in a building and the associated carbon impacts, measuring both the carbon stored in the wood building products and the greenhouse gas emissions avoided by choosing wood instead of more energy-intensive building materials.

Stella, a 244-unit multi-family housing development in Marina del Rey, California, avoided nearly 10,000 metric tons of CO_2 emissions and stored almost 4,500 metric tons of CO_2 by framing with wood. This equalled the carbon equivalent of taking more than 2,600 cars off the road for one year.

Source: WoodWorks

Volume of wood:
2.3 million board feet (equivalent)

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

Carbon stored in the wood:
4,495 metric tons of CO_2

Avoided greenhouse gas emissions:
9,554 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
14,049 metric tons of CO_2

EQUIVALENT TO:

2,683 cars off the road for a year

Energy to operate a home for 1,194 years

Source: US EPA

Photos: GLJ Partners

CASE STUDY: OREGON CONSERVATION CENTER

Location: Portland, Oregon; Architect: Lever Architecture; Photo: Jeremy Bittermann, Lara Swimmer, Shawn Records

Photo courtesy: Jeremy Bittermann
Photo source: https://www.woodworks.org/project/oregon-conservation-center/

The renovation and expansion of the Oregon Conservation Center utilized both mass timber and light wood-frame construction to reimagine an outdated office building. The building's collaborative interior reflects the environmental mission of its main tenant, The Nature Conservancy. Building designers specified glulam columns and beams and with cross laminated timber (CLT) panels manufactured in Oregon from FSC-certified lumber. Rooftop solar panels provide 25 percent of the building's electrical needs. By incorporating ample daylighting and efficient mechanical systems, the building has lowered its electricity usage by more than half. Wood interiors are exposed to create a warm, natural aesthetic; designers also used wood as the building's exterior siding to provide a durable finish. This project qualified for LEED Gold certification and has received numerous design awards.

Wood building materials also provide benefits for the ongoing operating efficiency of a building. Wood has a relatively high R-value which provides good insulating value. Wood also has lower thermal conductivity than other materials such as steel or concrete, making wood-framed buildings more efficient to insulate.[20] Light-frame wood, mass timber and prefabricated wood construction can all be used to create an efficient building envelope.

One of the most effective ways to improve indoor air quality is to reduce the use of materials that emit pollutants. Wood's natural beauty can also be left exposed to a building's interior, eliminating the need for additional interior finishes which could add VOCs. The Oregon Conservation Center in Portland, Oregon, left its wood structure exposed to the interior, creating a natural finish for tenants.

Demand for wood products provides an incentive for forest owners to keep their lands actively managed and healthy. A young, growing forest produces 1 ton of oxygen and absorbs 1.4 tons of CO_2 for every 1 ton of wood.[21] When a forest is left unmanaged, older trees eventually stop absorbing carbon from the atmosphere and then release carbon when they decompose or die from wildfire, insect damage or disease.

WOOD BUILDING SYSTEMS

Wood construction can support green building of many occupancy types, including multi-family, mixed-use, office, industrial, education, healthcare and more. Three common framing types all provide green building benefits.

Light-Frame

Light-frame is the most common form of wood construction, accounting for roughly 80 percent of wood-framed construction in the U.S. Wood can be used in structural applications such as roof, floor, and wall framing but also for other components such as doors and windows, exterior and interior finishes, trim, siding and decking.

The two predominant types of light-frame wood construction are:

- Type III, used primarily for multifamily residential building
- Type V, which permits wood to be used for all structural elements of the building

The Orchards at Orenco project in Hillsboro, Oregon is a good example of a light-frame wood structure that added sustainable value through its energy efficiency. Designers used 2x10 dimensional lumber to frame the walls, which gave them width to add extra insulation, reducing overall energy use of the complex by 60 to 70 percent.

Mass Timber

Mass timber framing uses large, solid wood members for walls, roofs and floor structures. Common mass timber building components include glue-laminated (glulam) beams, cross laminated timber (CLT), nail-laminated timber (NLT), dowel-laminated timber (DLT) and others. Mass timber fits green building goals in several ways. It replaces other more carbon-intensive structural materials with a renewable and carbon sequestering option. Mass timber components are fabricated offsite to precise specifications, which reduces waste, speeds construction and lowers labor costs; it also results in improved energy efficiency because the controlled fabrication process means they can build a tighter building envelope with fewer air gaps. Type IV, also known as heavy timber construction, first included CLT in 2015. The 2021 International Building Code (IBC) will allow mass timber structures of 8, 12 and 18 floors. Tall wood structures make efficient use of building sites, another consideration for green building certification.

Prefabricated or Modular Wood

Use of prefabricated assemblies and full modular construction is growing because both approaches offer many benefits to green building in terms of efficient, cost-effective approaches. Both are suitable for light-frame wood and mass timber construction of multi-family, office, retail and other types of building occupancies. A 2019 study by McKinsey & Company found that modular construction can trim costs by 20 percent and speed schedules by up to 50 percent.[22] Precise fabrication also improves the quality of the building envelope by improving airtightness. Plus, the controlled material procurement process ensures that certified materials are used.

GREEN BUILDING CODES

When building codes initially began focusing on green building, they were primarily concentrated on improving energy efficiency. Now, building codes reflect a broader global movement to mitigate the impacts of the built environment by promoting material resource efficiency, waste reduction, indoor air quality, site selection and utilization, and

more. Green building codes are designed to take a project beyond the minimum requirements in terms of energy efficiency and sustainable features. While many jurisdictions have their own requirements for sustainable building, the IgCC and CALGreen are among the most influential.

International Code Council's 2018 *International Green Construction Code* (IgCC)

The IgCC is considered an overlay code because it is consistent with other International Code Council (ICC) model building codes, including the International Building Code (IBC). The IgCC covers all types of new and existing commercial buildings, and establishes minimum regulations using both prescriptive and performance-related provisions. Some jurisdictions recognize the IgCC as an equivalent standard to LEED certification requirements; other jurisdictions have chosen to adopt only specific parts of the IgCC.

The IgCC was launched in 2009 and there have been many updates and improvements to the code since. One of the most important updates can be found in the 2018 edition of IgCC, which incorporated the provisions of ASHRAE Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, to provide designers with a unified green building code.

The IgCC takes an integrated, whole-building approach to green building design, incorporating measures that address the efficiency and sustainability of an entire building project and encouraging the use of low-impact materials and construction techniques. Most references to wood use are found in the Materials and Resources chapter, which covers the environmental and human health impacts of materials, including resource conservation, reduced life cycle impacts of building materials, impacts on the atmosphere, product transparency and waste management.

Many IgCC requirements overlap those of the green building certification programs. For example, several LEED v4 credits correspond directly with specific requirements of the 2018 IgCC.[23]

2019 CALGreen

California was the first state in the U.S. to adopt a state-mandated green building code. CALGreen was first published in 2009 with four goals: reduce greenhouse gas emissions from buildings; promote environmentally responsible, cost-effective, healthier places to live and work; reduce energy and water consumption; and respond to the environmental directives of the administration. Their original goal was to reduce greenhouse gases to 1990 levels by 2020.[24]

The code covers regulations for energy and water efficiency and conservation, material conservation and resource efficiency, environmental quality, and more. It also details jobsite waste reduction guidelines. CALGreen considers LCAs, using Athena Impact Estimator, GaBi and SimaPro LCA tools.

ENERGY EFFICIENCY IN GREEN BUILDING

To be considered truly sustainable, green buildings should also be energy efficient. There are many ways to reduce heat loss and improve energy efficiency in a building. Two of the most well-known energy-efficient-oriented design strategies are Net Zero and Passive House.

Net Zero Energy Building

A Net Zero (also known as Zero Energy) building is designed and constructed so that its energy use is powered exclusively by renewable sources, like solar. This limits a building's dependence on fossil fuels, reducing its lifetime carbon emissions.

A number of organizations provide a net zero certification or designation. The U.S. Green Building Council added LEED Zero, a complement to their LEED program which certifies the achievement of net zero energy goals. A net zero energy building earns the maximum number of points under the Building Energy Quotient criteria plus bonus points in the Green Globes program. The International Living Future Institute (who oversees the Living Building Challenge program) also has a Net Zero Energy Certification program.

It is important to distinguish between a 'green building' and a 'Zero Energy building'. The goal of green building is to use resources efficiently and reduce a building's impact on the environment. A Zero Energy building is focused on one primary green building goal, which is to reduce or eliminate energy use throughout a building's life.

A growing number of cities and jurisdictions are showing interest in the benefits of Net Zero building. For example, the state of California now requires that all new single- and multi-family projects up to three stories high meet Net Zero requirements. By 2030, all new commercial buildings in California must meet Net Zero requirements.

Passive House

Originally developed in Europe, Passive House is a voluntary design and construction standard for new and existing buildings. This whole building design strategy creates buildings with highly efficient envelopes that deliver consistent energy performance and indoor comfort.

Passive House certification in the U.S. can come from the Passive House Institute (PHI) or Passive House Institute US (PHIUS, with the PHIUS+ Passive Building Standard for North America). For example, Passive House projects which receive certification through PHI or PHIUS may earn LEED credits by documenting energy improvement which exceeds the requirements of ASHRAE 90.1-2010, *Energy Standard for Buildings Except Low-Rise Residential Building*.[25]

While each program has specific requirements, Passive House design employs five basic principles:[26 27]

1. Superinsulate the building envelope (for example, adding enough insulation to double or triple the heat resistance for a building in a cold climate)
2. Create a design with continuous insulation through the entire building envelope to avoid thermal bridging
3. Develop an airtight building envelope to limit air infiltration
4. Incorporate high performance windows and doors because these are key sources of heat loss
5. Include advanced heating and cooling systems with ventilation recovery

CASE STUDY: THE ORCHARDS AT ORENCO

Location: Hillsboro, OR; Architect: Ankrom Moisan Architects, Inc.

This three-story 57-unit wood-framed multi-family affordable living project is certified Passive House, meeting stringent energy efficiency requirements. In fact, at the time it was completed, The Orchards was the largest certified multi-family Passive House project in North America. Wood framing helped the project achieve the aggressive energy efficiency goals; 2x10 wall framing allowed designers to super-insulate the walls and add blown-in fiberglass insulation to the stud cavities as well as 1-1/2 inches of rigid mineral wool insulation to the exterior. By taping the plywood sheathing to reduce air gaps, the project team created a tight air barrier. At the roof, exterior walls were framed to the bottom of the roof sheathing so that the air barrier and insulation could continue up and over the light-frame wood trusses, which were ledgered to the inside face of the exterior wall. Designers also relied on wood's inherent insulating properties, incorporating details to encapsulate fasteners that would have otherwise created thermal bridges. Overall, through design choices, the expected energy use from heating was reduced by 90 percent and overall energy use was reduced by 60 to 70 percent, compared to a similar building.

Photo courtesy: Ankrom Moisan

CASE STUDY: MOUNTAIN EQUIPMENT CO-OP (MEC) HEADQUARTERS

Location: Vancouver, Canada; Architect: Proscenium Architecture + Interiors Inc.

The Vancouver-based headquarters of Canada's largest outdoor gear retailer is a spacious open concept plan, maximizing the warmth and beauty of its nail-laminated timber construction.

Interior Douglas-fir millwork screens offer an inviting alternative to traditional office cubicles. A double-beam configuration serves double duty: the exposed beams give warmth and architectural interest to the interior and their increased stiffness reduces deflections and floor vibrations. This acoustic benefit helps minimize distractions in an open office environment. The facility is estimated to be 70% more energy efficient than a traditional structure of the same size.29 It is certified LEED Platinum.

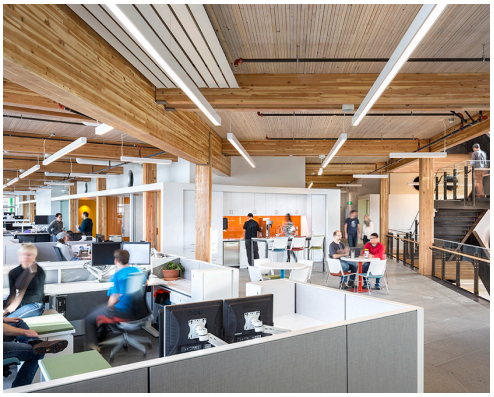

Photo courtesy: Ed White (https://rethinkwood.filecamp.com/s/NkH6ynmstgnCLunD/fi)

Using Passive House design, the Orchards at Orenco in Hillsboro, Oregon uses as much as 90 percent less energy for heating and cooling and up to 70 percent less energy overall than a similar building of the same type and size.[28]

It is possible to meet both Passive House and Net Zero qualifications for the same building. Passive House design is particularly well-suited for residential, multi-family and mixed-use construction, where long-term energy performance adds so much value.

CONCLUSION: NATURALLY GREEN

The construction industry has a sizable impact on carbon emissions, and building material choice can have a major influence on carbon emissions. While there are many ways to build sustainably, it is important for designers to take a fresh look at one of the original green building products–wood. Wood grows naturally, is renewable and reusable.

There are many tools, including lifecycle assessment analyses, forest certification programs and environmental product declarations, to help designers assess wood's sustainability. Green building rating systems recognize wood's contribution, offering credits for its use. Wood has a lighter carbon footprint than other building materials. Wood also contributes to the long-term energy efficiency of a structure, which adds to its sustainability over time.

As emphasis on green building grows, it's important for designers to understand their options for sustainable design. No one material is the answer for every project, but in many instances, wood can contribute to meeting green building goals. ■

QUIZ

1. The term, embodied carbon, is defined as:
   a. Carbon emitted by using energy to power, heat and cool a building over time
   b. Carbon absorbed as a product such as wood is grown
   c. Carbon emitted from the energy required to produce, transport and use a product
   d. Carbon released when a product is burned

2. Which of the following is not used for LEED v4.1 certification?
   a. SFI
   b. WBLCA
   c. EPDs
   d. WoodWorks Carbon Estimator
   e. All are used

3. What is the purpose of an Environmental Product Declaration?
   a. A way to measure a whole building's efficiency
   b. A way to evaluate a product's lifetime environmental impacts in terms of embodied energy, emissions and waste generation
   c. A way to ensure that the wood was harvested from a sustainably managed forest
   d. A measure of the airtightness of a building design

4. Which of the following green building programs can be used to certify a 5-over-2 light-framed office structure?
   a. National Green Building Standard
   b. Green Globes
   c. LEED v4.1
   d. B and C only
   e. All of the above

5. The Forest Certification process is designed to:
   a. Meet a requirement for all Federal and state forestlands
   b. Ensure that the landowner followed sustainable forest management practices
   c. Ensure that chain-of-custody has been followed
   d. Track endangered species

6. According to the course materials, one of the most effective ways to improve indoor air quality is:
   a. Build with materials that emit high VOCs
   b. Increase the carbon footprint through specifying materials
   c. Create a local project team with less travel time required
   d. Reduce the use of materials that emit pollutants

7. Which of the following statements is FALSE?
   a. Passive House buildings use up to 90 percent less energy for heating and cooling
   b. Net Zero buildings must get all their energy for operations from renewable sources
   c. Net Zero building design requires that renewable building materials be used in construction
   d. A building can be designed to meet both Net Zero and Passive House requirements
   e. All are true

8. Mass timber construction supports green building goals because:
   a. All mass timber projects are built to meet LEED criteria
   b. All mass timber buildings meet Passive House requirements
   c. The lumber used to build CLT is required to come from a certified forest
   d. Prefabricated mass timber components fit to precise specifications, which creates a tighter building envelope and improves energy efficiency
   e. Mass timber projects automatically qualify for Four Green Globes

9. Why does continued demand for wood products benefit the environment?
   a. Young, growing forests absorb more carbon than older stands
   b. When forests are not actively managed, they become more susceptible to insect damage, disease and wildfire
   c. Wood requires less energy for production than steel or concrete
   d. All of the above

10. How does use of wood lower a building's carbon footprint?
    a. It is the only building material that can be recycled
    b. It is always sourced from certified forests
    c. It has higher avoided greenhouse gas emissions than other materials
    d. It has a lower R-value than other building materials

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REFERENCES

1. Survey: Architect Perspectives On The Future Of Wood, AIA & Think Wood, 2019
2. Urban Land Institute, https://americas.uli.org/wp-content/uploads/ULI-Documents/Greenprint-Embodied-Carbon-Report_FINAL.pdf page 4
3. *Carbon Implications of Building Materials Selection, Dovetail Partners*, https://www.woodworks.org/wp-content/uploads/15NC01-BOWYER-Carbon-implications-of-Material-Selection-WSF-160323.pdf
4. Architecture 2030, https://architecture2030.org/buildings_problem_why/
5. *Doing Right by Planet and People, The Business Case for Health and Wellbeing in Green Building*, World Green Building Council, April 2018, https://www.worldgbc.org/sites/default/files/WorldGBC%20-%20Doing%20Right%20by%20Planet%20and%20People%20-%20April%202018_0.pdf
6. CORRIM.org; Cooperative Extension, United States Department of Agriculture, https://wood-products.extension.org/life-cycle-assessment-of-forest-products-wood-is-good/
7. Alvarez, Mila. 2018. The State of America's Forests. Greenville, SC: U.S. Endowment for Forestry and Communities, Inc., www.arcgis.com/apps/MapJournal/index.html?appid=dfe7da49c651424eb39a14c61c4d5f7f
8. *National Forest Certification Study; An Evaluation of the Applicability of Forest Stewardship Council (FSC) and Sustainable Forest Initiative (SFI) Standards on Five National Forests*, Pinchot Institute for Conservation, https://www.fs.fed.us/projects/forestcertification/executive-summary.pdf
9. Washington State Department of Natural Resources, https://www.dnr.wa.gov/programs-and-services/product-sales-and-leasing/timber-sales/forest-certification
10. *Oregon Forest Facts 2017 - 18 Edition*, Oregon Forest Resources Institute, https://www.oregonforests.org/sites/default/files/2017-05/OFRI_FactsFacts_1718_WEB_1.pdf
11. USGBC, https://www.usgbc.org/credits/existing-buildings-schools-existing-buildings-retail-existing-buildings-data-centers-exis-92
12. APA Standards, https://apawood-europe.org/official-guidelines/european-standards/individual-standards/2273-2/
13. American Wood Council; https://awc.org/sustainability/epd
14. Dovetail Partners, Inc., https://www.woodworks.org/wp-content/uploads/WEB110-BOWYER-EPDs-HPDS-LEED-v4-Webinar-160608.pdf
15. ISO 14025, https://www.iso.org/standard/38131.html
16. ISO 21930, https://www.iso.org/standard/61694.html
17. NGBS Green Certified Products, https://www.homeinnovation.com/services/certification/green_certified_products/browse_green_certified_products?cat=2#grid
18. Performance Rated Panels, F405, APA-The Engineered Wood Association, www.apawood.org
19. Dovetail Partners Inc., https://www.woodworks.org/wp-content/uploads/15NC01-BOWYER-Carbon-implications-of-Material-Selection-WSF-160323.pdf
20. Thermal Conductivity of Wood Compared with Other Materials, American Wood Council, https://www.awc.org/faqs/general/what-is-the-thermal-conductivity-of-wood-and-how-does-it-compare-to-other-materials
21. Sustainable Buildings, Sustainable Future, APA – The Engineered Wood Association, https://www.apawood.org/publication-search?q=F305&tid=1
22. *Modular Construction: From Projects to Products*, McKinsey & Company, June 18, 2019; https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/modular-construction-from-projects-to-products
23. *Alignment of LEED and the 2018 IgCC*, U.S. Green Building Council; https://www.usgbc.org/sites/default/files/LEEDv4-IgCC-aligned-measures_0.pdf
24. California State Building Standards Commission, https://www.dgs.ca.gov/BSC/Resources/Page-Content/Building-Standards-Commission-Resources-List-Folder/CALGreen
25. U.S. Green Building Council, https://www.usgbc.org/leedaddenda/10486
26. PHIUS, https://www.phius.org/what-is-passive-building/passive-house-principles
27. PHI, https://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm
28. PHIUS, https://www.phius.org/phius-certification-for-buildings-products/case-studies/orchards-at-orenco-phase-i
29. https://www.fastepp.com/portfolio/mec-head-office/