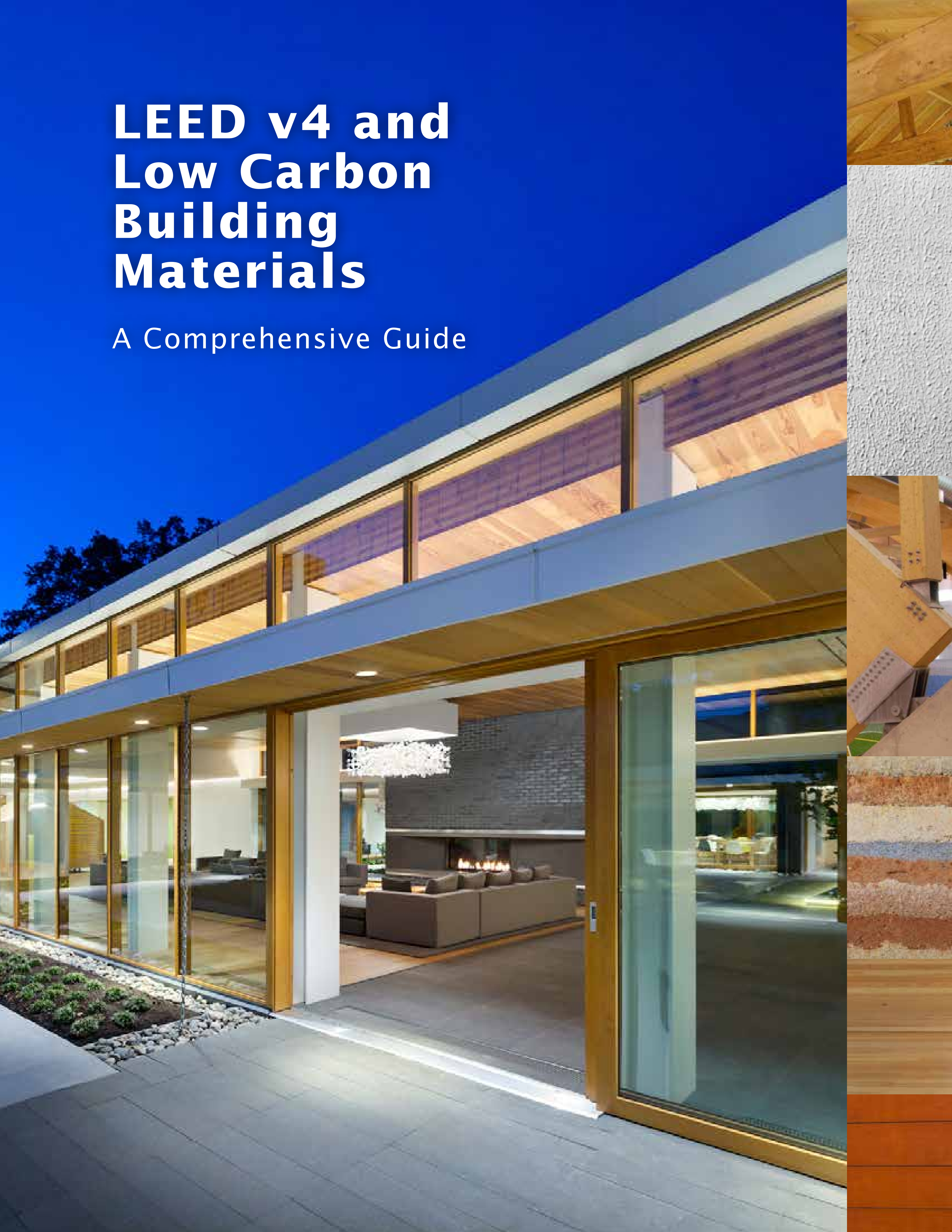
LEED v4 and Low Carbon Building Materials

A Comprehensive Guide



Cover image: Ronald McDonald House BC Yukon, Vancouver B.C.
Photo: Ema Peter

Exterior of the Wood Innovation & Design Centre in Prince George, B.C.. Photo: Ed White

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Acronym List

ACP	Alternative Compliance Paths
ATFS	American Tree Farm System
B.C.	British Columbia
BCBC	British Columbia Building Code
BPDO	Building Product and Optimization
CAC	Cement Association of Canada
CaGBC	Canada Green Building Council
CARB	California Air Resources Board
CDPH	California Department of Public Health
CLT	Cross-laminated timber
CO_2e	Carbon dioxide equivalent
CNC	Computer numerical control
CSA	Canadian Standards Association
CSR	Corporate Social Responsibility
CWC	Canadian Wood Council
DLT	Dowel Laminated Timber
EA	Energy and Atmosphere (LEED category)
EPD	Environmental Product Declaration
EPR	Extended Producer Responsibility
FII	Forestry Innovation Investment
FSC	Forest Stewardship Council
GGBFS	Ground Granulated Blast Furnace Slag
GHG	Greenhouse Gas
Glulam	Glued laminated timber
GWP	Global Warming Potential
HPD	Health Product Declaration®
IEQ	Indoor environmental quality
IP	Integrative Process
LCA	Life-cycle assessment
LEED	Leadership in Energy and Environmental Design
BD+C	Building Design and Construction (LEED category)
LT	Location and Transportation (LEED category)
LSL	Laminated Strand Lumber
LVL	Laminated Veneer Lumber
MDF	Medium-density fiberboard
MR	Materials and Resources (LEED category)
NBC	National Building Code
NC	New Construction (LEED rating system)
NLT	Nail-Laminated Timber
OECD	Organization for Economic Co-operation and Development
OSB	Oriented Strand Board
PCA	Portland Cement Association
PCR	Product Category Rules
PEFC	Programme for the Endorsement of Forest Certification

Acronym List Continued

PLC	Portland-limestone Cement
RP	Regional Priority (LEED credit)
SAN	Sustainable Agricultural Network
SCAQMD	South Coast Air Quality Management District
SCL	Structural Composite Lumber
SCM	Supplementary Cementitious Materials
SFI	Sustainable Forestry Initiative
SIPs	Structural Insulated Panels
STS	Self-Tapping Screws
ULEF	Ultra-low Emitting Formaldehyde
USGBC	U.S. Green Building Council
VOC	Volatile Organic Compounds

Executive Summary

L'École Mer et Montagne, Campbell River Photo: Derek Leper

Buildings have a significant impact on our economic, social and environmental well-being. Buildings account for 11% of B.C.'s Greenhouse Gas (GHG) emissions.[1] With life spans of 50–100 years, today's buildings will impact our energy use and emissions for the next century.

Reducing GHG emissions from the built environment has been identified as an important priority in reducing overall human-induced GHG emissions. Commitment to reducing embodied carbon in buildings is demonstrated the Canada Green Building Council (CaGBC)'s Zero Carbon Buildings Initiative[2] and the new Leadership in Energy and Environmental Design (LEED®) version 4 rating system. This guide will discuss ways in which low carbon building materials may be used to achieve credits in LEED v4.

Embodied carbon emissions (GHG emissions) are produced during the manufacture, transportation, manufacturing, construction, maintenance, and disposal of the products and materials that go into buildings. For most types of buildings, embodied carbon accounts for a significant amount of the building's total GHG emissions, the majority of which occur prior to building occupancy.

Wood and Portland-limestone Cement (PLC) are two building materials that offer opportunities to reduce the embodied carbon of a building. The low energy consumption required in wood product manufacturing results in lower embodied carbon emissions than from the production of other building materials, in addition to the carbon stored (sequestered) in the wood for the life of the building. Portland-limestone cement has lower embodied carbon than traditional cements, in addition to the CO2 concrete absorbs (sequesters) through carbonization during the building's life.

A variety of wood products are manufactured in B.C. and PLC is manufactured by two suppliers in the Lower Mainland. The close proximity to local manufacturing plants reduces CO_2 emissions associated with the transportation of products to construction sites, while contributing to the growth of local industry and B.C.'s economy.

In addition to the provincial and national initiatives noted above, which encourage the uptake of low carbon materials in buildings, B.C.'s Wood First Initiative[3] further encourages the use of wood as a building material, supporting local industry and reducing environmental impact.

As a structural material, wood has been used in many building applications, such as:

- Glue-laminated timber (Glulam)
- Structural composite lumber (SCL)
- Small dimensional lumber
- Mass timber, which takes many forms, the most commonly seen include:
    - Cross-laminated timber (CLT)
    - Laminated veneer lumber (LVL)
    - Laminated strand lumber (LSL
    - Dowel Laminated Timber (DLT)
    - Nail-laminated lumber (NLT or nail-lam)

Wood is also frequently used as an architectural element, bringing warmth to a space. As a Biophilic design attribute, the integration of natural materials such as wood into the built environment can also specifically benefit human health.[4]

The use of wood as an architectural element includes applications such as:

- Cladding
- Wood finishes
- Ceiling, wall and floor finishes
- Millwork and trim
- Doors
- Furniture

1 BC Climate Leadership Plan (2016a). URL: https://climate.gov.bc.ca/
2 Zero Carbon Building Initiative (2016). URL: https://www.cagbc.org/zerocarbon

3 Wood First Initiative (n.d.). URL: http://www2.gov.bc.ca/gov/content/industry/forestry/supporting-innovation/wood-first-initiative
4 Kellert, S. & Calabrese, E. (2015). The Practice of Biophilic Design. URL: http://www.biophilic-design.com/

PLC (branded in Canada as Contempra®) was first introduced to the Canadian market in 2011, although it has been used in Europe for over 25 years. European PLC allows up to 35% limestone in the clinker phase, resulting in nearly double the CO_2 emissions reductions per unit when compared with Canadian and US-based PLC products. Canadian PLC is produced by integrating regular Portland cement clinker with 6-15% limestone, resulting in 10% less CO_2 than regular Portland cement. The United States has allowed the use of PLC since 2006, with the same maximum 15% limestone threshold as Canada. The PLC used in Canada is structurally equivalent to regular Portland cement, which explains the current allowable limestone threshold of 15%.

In addition to wood and PLC products, there are other low carbon building materials currently available within the Canadian and US markets including:

- Supplementary Cementitious Materials (SCM)
- Rammed earth
- Bio-fiber blocks
- Strawbale
- Hempcrete

The low carbon products listed above are more frequently associated with residential applications, however, commercial and larger-scale building product applications do exist.

Since 2007, the B.C. government has required that all public sector buildings newly constructed or undergoing major renovations achieve LEED Gold or equivalent certification. As a green building rating system, LEED v4 for Building Design and Construction (LEED v4: BD+C) rewards projects that use low carbon building materials. As the most current version of the LEED rating system, v4 underwent significant changes compared with previous updates to the system; these changes are addressed in Section 3. There are six specific rating systems in the LEED v4: BD+C system that are applicable to B.C. public sector buildings:

- BD+C: New Construction
- BD+C: Core and Shell
- BD+C: Schools
- BD+C: Data Centers
- BD+C: Warehouses and Distribution Centers
- BD+C: Healthcare

The Materials and Resources (MR) category of the LEED rating system was the most affected by the changes compared to other categories. Significant structural changes to the credits resulted in the creation of new credits and/or credit sections. Wood, PLC and other low carbon building materials can contribute toward satisfying the following nine LEED v4 MR credits:

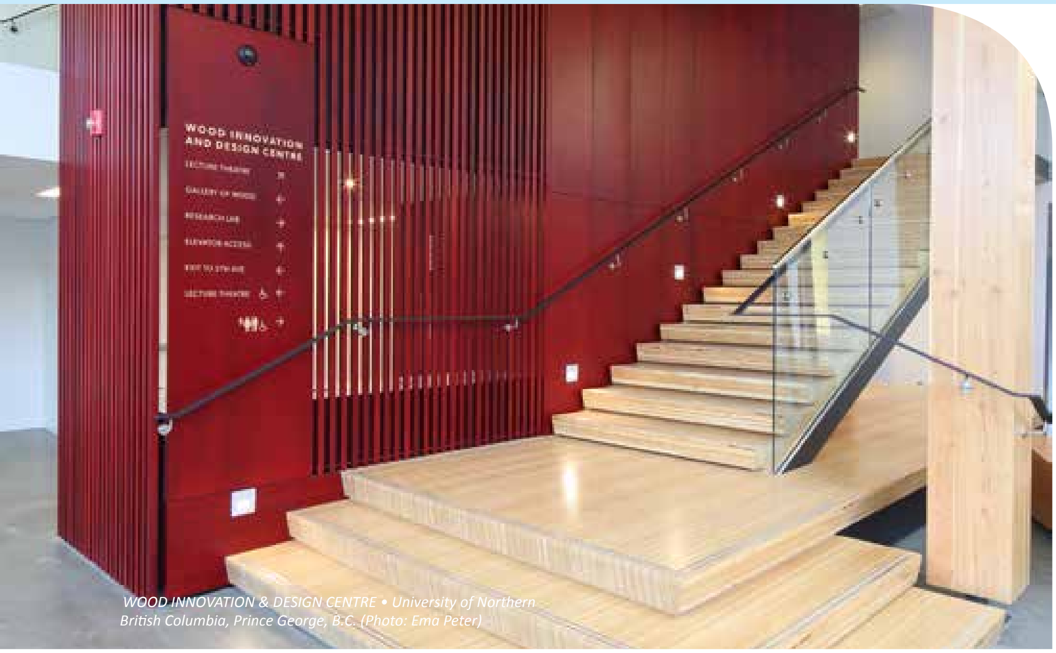
- MR: Building Life-Cycle Impact Reduction
- MR: Building Product Disclosure and Optimization (BPDO) - Environmental Product Declarations
- MR: BPDO - Sourcing of Raw Materials
- MR: BPDO - Material Ingredients
- MR: Furniture and Medical Furnishings (Healthcare only)
- Indoor Environmental Quality (IEQ): Low-Emitting Materials
- IEQ: Indoor Air Quality Assessment
- Innovation: Innovation
- Regional Priority: Regional Priority, Specific Credit

In addition, the use of low carbon materials may contribute to other prerequisites and credits, such as:

- Energy and Atmosphere (EA): Minimum Energy Performance
- EA: Optimize Energy Performance
- IEQ: Minimum Acoustic Performance (Schools only)
- IEQ: Acoustic Performance

Using low carbon building materials, such as wood and PLC, creates opportunities for project teams to reduce a project's environmental impact, and support local industry. Projects that choose low carbon building materials will also have an opportunity to target and achieve LEED credits. As emphasis on low carbon building materials continues to grow, B.C. is demonstrating environmental leadership by expanding its low carbon materials use in public sector projects.

1.0 Introduction to the Guide



WOOD INNOVATION & DESIGN CENTRE • University of Northern British Columbia, Prince George, B.C. (Photo: Ema Peter)

The green building industry has long looked at ways to promote and reward the use of environmental building materials but has historically fallen short of directly rewarding low carbon building materials. LEED, the most popular and long-lived green building rating system in North America, rewards the use of recycled or repurposed materials, local materials, sustainable agricultural materials, and certified wood products via points under the Materials and Resources category. All of these sustainable materials contribute to reducing the construction industry's use of finite resources and can contribute to reducing the carbon intensity of a building.

Increasing industry focus on the use of low carbon building materials is apparent. In 2013, the United States Green Building Council (USGBC®) released the newest version of LEED, known as LEED version 4 (LEED v4).[5,6] LEED v4 became mandatory for any project pursuing LEED in Canada on or after November 1, 2016. LEED v4 saw a complete reboot of the rating system, including significant changes to the MR category. LEED now directly rewards projects that choose a lower carbon structural material, such as wood or PLC.

In addition to LEED v4, the Canada Green Building Council (CaGBC®) recently released their Zero Carbon Buildings Initiative[7], which is developing a national framework for commercial, institutional and high-rise residential buildings constructed to net zero carbon standard by 2030.[8] Embodied carbon of building materials has been identified as one of four key areas of focus for this work.

Since 2007, the B.C. government has required that all new public sector

LEED now directly rewards projects that choose a lower carbon structural material, such as wood or PLC.

5 United States Green Building Council (2017). URL: www.usgbc.or
6 LEED v4, the Newest Version of LEED Green Building Program Launches at USGBC's Annual Greenbuild Conference (2013). URL: http://www.usgbc.org/articles/leed-v4-newest-version-leed-green-building-program-launches-usgbc%E2%80%99s-annual-greenbuild-confe
7 CaGBC Zero Carbon Buildings Initiative (2016). URL: https://www.cagbc.org/zerocarbon
8 Canada Green Building Council (2017). URL: www.cagbc.org.

This guide will serve as an educational resource for using low carbon and renewable materials in LEED v4: Building Design + Construction (BD+C) projects.

buildings, including those undergoing major renovations, achieve LEED Gold or equivalent certification.[9]

This guide will serve as an educational resource for using low carbon materials in LEED v4: Building Design + Construction (BD+C) projects. The guide will provide an overview of the LEED rating system, including major changes between LEED Canada New Construction (NC) 2009 and LEED v4: BD+C, when and how to use wood and PLC, and provide insight into other alternative low-carbon building materials such as rammed earth and the bio-fiber modular block system.

9 Reducing Greenhouse Gas Emissions (n.d.). URL: http://www2.gov.bc.ca/gov/content/environment/climate-change/policy-legislation-programs/carbon-neutral-government/reduce

Nanaimo Energy Recovery Centre, Nanaimo, B.C. (Image courtesy of Associated Engineering).


Prince George Airport, Prince George, B.C. Photo: Equilibrium

Comprehensive Guide

LEED v4 and Low Carbon Building Materials

2.0 Introduction to Low Carbon Building Materials

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2.1 What makes a material low carbon?

Traditionally the building industry has focused on the carbon emissions from building operations, including space heating and cooling and lighting. Because the built environment is responsible for 11% of B.C.'s GHG emissions, significant attention has been given to the energy performance of buildings.[10] In recent years, carbon emissions associated with building products have received increasing levels of attention in Europe and North America, with the recognition that a significant portion of human-induced carbon emissions come from the building products industry. The CaGBC is now considering the impacts of building materials on carbon emissions through the [Zero Carbon Buildings Initiative.](https://www.cagbc.org/zerocarbon)[11]

The embodied carbon of a building is the sum of the carbon emitted during the extraction of raw materials, transportation, manufacturing, transportation to building site, through construction, maintenance and decomissioning. Considering the impact of carbon in building design and construction can lead to a change in what building materials are used and where the materials are located and extracted.

A note about carbon

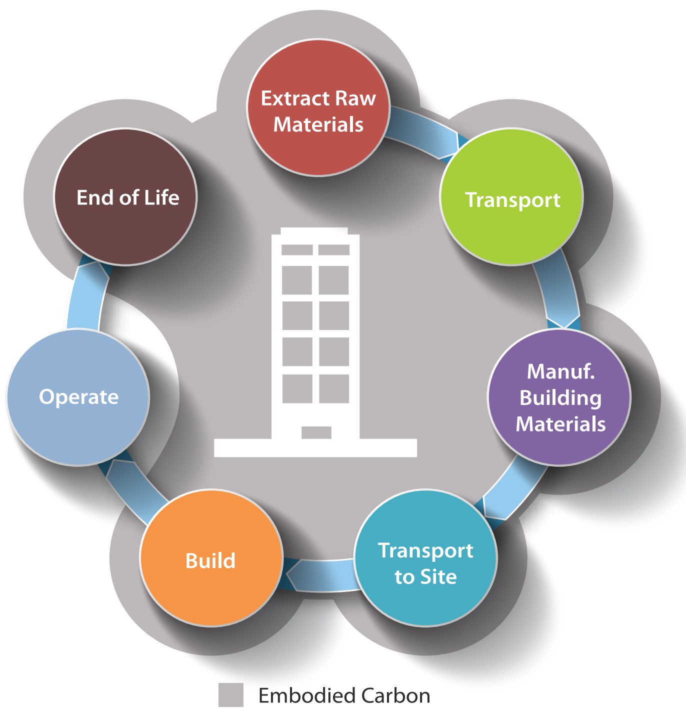
Carbon is the commonly used shorthand for carbon dioxide, CO_2, a GHG that is released to the atmosphere where it traps heat radiating from the earth from both person-made and natural sources. There are other GHGs that contribute to this effect, such as methane (CH_4), nitrous oxide, (NO_2), and sulfur hexafluoride (SF_6), each with a different heat trapping potency. Global Warming Potencial (GWP) is a measure of of this potency. For example, with a GWP of 25, releasing one tonne of CH_4 is the equivalent of releasing 25 tonnes of CO_2 and can therefore be represented as 25 tonnes as carbon dioxide equivalent (CO_2e). For reporting purposes, GHG emissions are often expressed in terms of tonnes of CO_2e.

10 BC Climate Leadership Plan (2016). URL: http://climate.gov.bc.ca/at-home-and-around-the-world/

11 CaGBC Zero Carbon Buildings Initiative (2016). URL: https://www.cagbc.org/zerocarbon

12 Embodied Energy and Carbon: The ICE Database (2016). URL: http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.WLDtsW8rJ0w

Figure 1: Embodied energy and carbon. The lifecycle of a building



Adapted from Circular Ecology[12]

Choosing low carbon building materials, such as wood and PLC, help to reduce a building's embodied carbon.[13,14] The following section will address how and when to use wood and PLC in building projects in B.C.

2.2 Wood

The benefits of wood as a building material compared with other traditional building materials, such as steel and concrete, are as follows:[15,16]

- Renewable
- Stores carbon
- Less energy to manufacture
- Durable
- Locally produced

The province of B.C. has adopted a Wood First Initiative, which is helping to support local B.C. industries, while promoting the use of wood in buildings. Wood is used in many applications in the built environment, including as a structural or architectural component.

2.2.1 Timber structures

Historically the use of wood in Canadian structures has relied on solid timber post-and-beam and light frame construction systems. The decline in the availability of large timbers, combined with historical concerns over the combustibility of wood, led to a shift in the use of wood from mid-rise buildings to low-rise structures, which could be produced economically using light frame construction.[17] However, modern research and innovations in the field of wood products have expanded the range of possibilities by efficiently combining wood materials using adhesives or metal fasteners, allowing for the use of smaller trees and improving the use of forest resources. Research in the field of fire engineering has also shown that heavy timbers exposed to fire may maintain load-bearing capacity while charring. Design procedures now exist that allow exposed timbers to achieve fire resistance ratings.[18]

Glued-laminated timber, or glulam, was first produced in the early 20th century and provides a cost effective method for achieving large member sizes. Glulam is manufactured by gluing together wood laminates, the quality and layup of which are engineered to control the properties of the member.

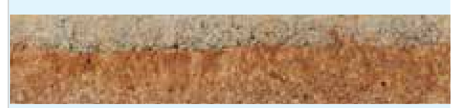
Structural composite lumber (SCL) products, such as laminated veneer lumber (LVL), laminated strand lumber (LSL), and parallel strand lumber (PSL), are produced by adhering sheets of thin wood veneers or veneer strands under pressure. The presence of the knots and other defects is diminished by adjacent veneers or strands, optimizing the use of the wood fibres. SCL products are produced using kiln-dried materials to achieve low moisture content and often incorporate some degree of cross-laminating, providing dimensionally stable elements less susceptible to shrinkage and cracking.

The low density of timber relative to steel and concrete means that timber structures

Consider selecting appropriate building materials for different applications and taking into account embodied carbon content.

Wood has a lower carbon footprint than steel or concrete, and its light weight can help to reduce foundation sizes.

Concrete provides a durable surface and, due to its high thermal performance, can be used as a thermal mass to regulate temperatures and reduce energy loads. Concrete is a great and necessary option for footings, foundations as well as a cap on other low carbon options such as rammed earth walls and in combination with wood to provide the best low carbon solutions.



13 Portland-Limestone Cement (n.d.). URL: http://www.cement.ca/en/Newsroom/Portland-Limestone-Cement.html

14 Shaw, C. (2010). Reducing GHG Emissions in the Cement Industry. URL: http://pics.uvic.ca/sites/default/files/uploads/publications/Reducing%20GHG%20emissions%20in%20the%20cement%20industry.pdf

15 Canadian Wood Council (2017). Wood Advantages. URL: http://cwc.ca/design-with-wood/durability/woods-heritage/wood-advantages/

16 Forest Products Association of Canada (2011). Feel Good About Canadian Wood. URL: http://www.fpac.ca/publications/building_green__EN_web_v2.pdf

17 FPInnovations (2014). Technical Guide for the Design and Construction of Tall Wood Buildings in Canada. FPInnovations Special Publication SP-55E, 1st ed, Pointe-Claire, QC.

18 CSA (2014). *Engineering Design in Wood.* CSA 086-14. Mississauga, ON: Canadian Standards Association (CSA).

Structural composite lumber products. From left-to-right: laminated strand lumber (LSL), parallel strand lumber (PSL), and laminated veneer lumber (LVL) (Image courtesy of Tom Joyce).

Stadthaus, Murray Grove in London, UK, was among the first in a new generation of tall timber buildings around the world, with eight-storeys of cross-laminated timber over a single concrete storey. Prefabrication, which included cutting openings and connection points, reduced the on-site assembly time to only 8 weeks for the timber structure. (Image courtesy of Waugh Thistleton. Photographer: Will Pryce).

tend to be lighter, reducing the size of foundations and any supporting structure. In seismic regions the reduced mass of timber buildings leads to lower lateral forces, further reducing the demands on the foundation.

The use of 3D modelling software and computer numerical controlled (CNC) machinery has greatly increased the opportunities for prefabrication in the timber industry. Suppliers are able to assemble structures digitally, identifying potential issues before the products arrive on site, allowing for accurate estimates of material quantities, and enabling complex geometries to be realized. Combined with CNC processing, 3D modelling allows for the production of timber elements with accurately-formed holes and cuts, increasing the ease of on-site assembly and providing tighter tolerances at connections.

Opportunities for prefabrication with timber extend from sections of light frame wall and floor sections (when produced with insulation between layers of sheathing, referred to as structural insulated panels (SIPs), and called cassettes in parts of Europe) to mass timber panel elements cut to match required geometries, fit connections, and provide openings or chases for services.[19]

In addition to new wood-based products, new timber construction and connection systems are available. Self-tapping screws (STS) are a recent addition to the Canadian market, and have been in use in Europe for over 10 years. STS come in a range of diameters and up to 1.0m long, with options for the length and nature of the screw threads and the shape of the head. The coarse threads and high strength steel used in their manufacture make STS particularly well-suited to resisting loads in withdrawal.

This has led to their use in a diversity of applications, including reinforcing members with notches, holes, or splits; connecting mass timber or pre-fabricated light-frame panels; and in pre-engineered dovetail connectors. STS or HBV connectors (glued-in perforated steel plates) have also been applied in the construction of timber-concrete composite floor systems, which use the high compressive strength and mass of concrete to achieve larger spans and dampen vibrations. For a further discussion of new timber connection technologies see Karsh (2014).[20]

19 TRADA (2009). "Case Study: Stadthaus, 24 Murray Grove, London." High Wycombe, UK: TRADA Technology.

20 Karsh, E. (2014). "Modern Timber Connections." *STRUCTURE Magazine*, Published jointly by the National Council of Structural Engineers Associations (NCSEA), Council of American Structural Engineers (CASE), and Structural Engineering Institute (SEI). August 2014.

Self-tapping screws. (Image courtesy My-Ti-Con[31]).

Small structures that meet the criteria of Part 9 of the British Columbia Building Code (BCBC)[21] or National Building Codes (NBC)[22] prescriptive design guidelines are provided in that Part; other structures may be designed per Part 4 using CSA O86, *Engineering Design in Wood*[23], and the *Wood Design Handbook*[24] published by the Canadian Wood Council (CWC). Additional resources for the design and use of wood products are provided by the CWC and their WoodWorks! program[25], the Forestry Innovation Investment (FII) and their naturally:wood program[26], and FPInnovations[27].

Light-frame timber

Timber structures may be constructed using a number of different systems. Light frame, or stick frame, construction uses small dimensional lumber with timber decking or wood-based sheathing panels to form floor and wall elements. Light frame systems are an economical solution for many low-rise structures, and have a long history of use in North America. Part 9 of the BCBC and NBC[29] provides prescriptive rules for the design of small and regular light frame structures based on practices found to be effective historically. Structures that deviate from the criteria for Part 9 must be designed to Part 3 of the BCBC or NBC.

Example of a pre-engineered aluminum dovetail connector during installation. (Image courtesy of My-Ti-Con).

Light frame structures often incorporate pre-engineered and engineered wood products, such as pre-engineered trusses and timber I-joists, prefabricated structural

21 British Columbia Office of Housing and Construction Standards (2012). *British Columbia Building Code.* Victoria, B.C..
22 National Research Council (NRC) (2015). *National Building Code of Canada.* Ottawa, ON.
23 CSA (2014). *Engineering Design in Wood.* CSA O86-14. Mississauga, ON: Canadian Standards Association (CSA).
24 CWC (2015). Wood Design Manual 2015. Canadian Wood Council (CWC). Ottawa, ON.
25 URL: http://wood-works.ca/
26 URL: http://www.naturallywood.com/
27 URL: https://fpinnovations.ca/
28 http://www.my-ti-con.com/

29 National Research Council (NRC) (2015). *National Building Code of Canada.* Ottawa, ON.

The Earth Systems Sciences Building at the University of British Columbia makes use of timber-concrete composite systems, with concrete topping contributing to the performance of the cross-laminated timber floor panels and supporting glulam beams. The feature stair (above) cantilevers into the atrium, with glued-in HSK plates connecting CLT elements. (Photo courtesy of Martin Tessler).

The roof of the gym at the Doig River Community Centre features glulam beams with steel tension rods to create an aesthetically striking and efficient design (Image courtesy of Derek Lepper).

insulated panels (SIPs), and structural composite lumber members.

Since 2009, the BCBC has permitted the use of light frame timber construction for structures within Group C, residential occupancy, up to a height of 6-storeys and subject to restrictions on building area, streets facing, and added requirements for fire separations. Structures having occupancies other than Group C are restricted in height and building area based on the occupancy type, with a maximum height outside of Group C of 4 storeys. The 2015 edition of the NBC includes revised criteria that extends combustible construction limitations to allow 6-storey structures subject to similar restrictions to the BCBC. Guidance on the design of tall wood buildings may be found in the *Technical Guide to the Design and Construction of Tall Wood Buildings in Canada* published by FPInnovations.[30]

Heavy timber frames

Structures with longer spans and wider column spacings than may be achieved with light frame, can be realized using heavy timber post-and-beam frames with glulam, SCL, or heavy timber elements. Roof and floor areas are typically made up of either mass timber panels or joists topped with wood-based sheathing panels, which span between larger timber beams. Timber beams can be combined with steel or concrete (in timber-concrete composite designs) to increase spans and reduce floor vibrations.

Joints in timber frames are typically designed to be pinned, with lateral forces resisted by bracing or shearwalls. In low and mid-rise structures, light frame, concrete, or masonry shearwalls are common, whereas for taller structures mass timber, concrete shearwalls or cores are necessary. Unlike with steel braced frames, buckling of timber braces is undesirable and ductility in seismic applications should be provided through yielding of steel plates or fasteners at connection points. Moment-resisting frames can be produced using timber to allow for unobstructed open spaces, however, close attention to the detailing and magnitude of perpendicular to grain tensile stresses is needed. A discussion of moment-resisting joint designs is given by Buchanan and Fairweather (1994).[31]

When wood is exposed to fire it burns and forms a charred layer, which insulates the remainder of the timber section and preserves the load-carrying capacity of the uncharred residual area. Studies on the behaviour of timber under exposure to fire and on the rate of growth of the char layer have led to the development of design procedures that allow heavy timber elements to be provided with a fire resistance rating (see Appendix B of CSA O86[32]). The procedure involves comparing the residual strength of the member cross-section after a time-dependent depth of charring has occurred against the effects of the loads acting on the member during a specified fire loading situation. The member may be rated for the longest duration of fire exposure for which the remaining capacity of the charred section exceeds the demands from the fire load case.

30 FPInnovations (2014). *Technical Guide for the Design and Construction of Tall Wood Buildings in Canada.* FPInnovations Special Publication SP-55E, 1st ed. Pointe-Claire, QC.

31 Buchanan, A. and Fairweather, R. (1994). Glulam connections for seismic design. In *Proceedings of the Pacific Timber Engineering Conference (PTEC).* Gold Coast, Australia. July 11-15, 1994. p. 528-537.

32 CSA (2014). *Engineering Design in Wood.* CSA O86-14. Mississauga, ON: Canadian Standards Association (CSA)

Mass timber

Mass timber is a term used to refer to a range of solid wood panel products, ranging in thickness in Canada from 45mm (1 3/4") to 381mm (15"). Common mass timber products currently on the Canadian market include cross-laminated timber (CLT), laminated veneer lumber (LVL), laminated strand lumber (LSL), and nail-laminated lumber (NLT).

The larger dimensions of mass timber panels relative to wood structural members is associated with typically greater capacities, which has led to the use of mass timber elements in a new generation of tall timber structures, including Brock Commons at UBC (case study on page 68), the Wood Innovation Design Centre in Prince George (case study on page 60), Stadthaus in London, UK (see page 10), and the feasibility study The Case for Tall Wood Buildings[33]. Recently mass timber products and systems have been the focus of significant research and testing in Canada; a large collection of results is available through the reThink Wood website.[34]

CLT was first produced in Europe in the early 1990s and has been available in Canada since 2011. Produced by gluing together layers of timber laminates each oriented at 90 degrees to each other, the panels exhibit high in-plane shear strength and stiffness, and may be used to span out-of-plane as roof and floor panels.[35] Mass timber panels may be used for both horizontal and vertical elements (see example on page 10 (Stadthaus side bar). Panels are typically modelled and cut by CNC to the necessary dimensions, then rapidly assembled on site using mainly self-tapping screws and light-gauge steel connectors. Due to their cross-wise laminating CLT panels are able to span partially in two directions and transfer loads around small openings. Further information may be found in the CLT Handbook published by FPInnovations.

NLT is a one-way spanning floor system composed of pieces of dimensional lumber stacked on end and nailed together. Varying depths of lumber pieces may be used with exposed ceilings and soffits to allow for concealment of some services and to break up the surface, improving acoustics.

2.2.2 Architectural components

Wood may also be used for architectural purposes, introducing warmth and a more natural feel into a space. Wooden elements may be used for cladding, interior finishes and furnishings.

Wood cladding

Wood is a beautiful, renewable and energy-efficient choice for exterior cladding. It is easy to install and replace, and is a renewable material that can support local economies. The diverse range of B.C. wood species available supplies a wide range of exterior products. Unlike other cladding materials, trees absorb carbon from the atmosphere as they grow, so when turned into wood products and used in building projects, the products store that carbon throughout its service life until it burns or

Wood may also be used for architectural purposes and introduces warmth and a more natural feel into a space.

33 McFarlane Green Biggar Architecture + Design (mbg) (2012). *The Case for Tall Wood Buildings*. Other contributors: Equilibrium Consulting, LMDG Ltd., BTY Group. Ottawa, ON: Canadian Wood Council (CWC).
34 reThink Wood (2017). Tall Wood / Mass Timber Research. reThink Wood website. URL: http://www.rethinkwood.com/tall-wood-mass-timber/research
35 FPInnovations (2011). CLT Handbook. FPInnovations Special Publication SP528E. Pointe-Claire, QC. Available online at: https://fpinnovations.ca/

Choose certified wood cladding harvested from sustainably managed forests, get it factory-primed and install it with good moisture protection.

The Pacific Autism Family Centre in Richmond, B.C., used pre-fabricated NLT floor panels supported on a glulam post-and-beam structure and NLT elevator shafts. (Image courtesy of naturally:wood).

decomposes, releasing carbon back into the atmosphere. If the trees are replaced, the process can remove more carbon than it generates, creating a temporary carbon sink generally for the life of the building.

A cavity wall, or rainscreen, is a popular choice of assembly for wood cladding. Different from mass walls like concrete and rammed earth or barrier walls such as precast concrete panels, a cavity wall contains an air space behind the cladding. Moisture is allowed to get past the cladding where it is stopped by a weather barrier and drained away from the building, and because the air pressure is equalized, moisture is not driven into the assembly.

Wood cladding is vulnerable to insects, rot, decay, mold, mildew, and UV degradation, so it has to be well protected with paints, stains, sealants, or charred (Shou Sugi Ban) as a finishing technique and then maintained regularly.[36] These coatings eventually will require maintenance throughout its service life, requiring materials, energy, and labor and depending on the choice of finish, possibly diminishing some of wood's environmental luster. Factory-priming wood minimizes emissions and waste from the painting process and makes the paint last longer, lowering maintenance.

Choose certified wood cladding harvested from sustainably managed forests, get it factory-primed and install it with good moisture protection. With periodic maintenance, wood cladding, particularly cedar, should last 50 years or more and represent a good balance of various environmental issues.[37]

36 Boddy, Trevor (2015). *The Apostle of Wood.* Canadian Architect Magazine. URL: https://www.canadianarchitect.com/features/1003730141/
37 Ehrlich, B. (2014). *Cladding: More Than Just a Pretty Façade.* Building Green, September 2, 2014. URL: https://www.buildinggreen.com/feature/cladding-more-just-pretty-fa-ade

The Wood Innovation Design Centre at the University of Northern British Columbia in downtown Prince George used the Shou Sugi Ban technique of creating a charred wood finish (Image courtesy of Ed White).

Wood finishes

Architectural wood finishes provide warmth and beauty to both interiors and exteriors and can be used on a number of building elements such as partitions, ceilings, floors, doors, millwork and trim to name a few. Incorporating wood into interior design can create a restorative environment, bringing in a biophilic design feature to the space and connecting the occupant with an indirect experience of nature.[38,39]

With a careful selection of a low VOC coating, wood can contribute to indoor air quality, provide a warm inviting environment as well as add artistic appeal and value to a project while contributing to the biophilic elements in a project.

38 Kellert, S., & Calabrese, E. (2015). The Practice of Biophilic Design. URL: http://www.bullfrogfilms.com/guides/biodguide.pdf

39 Augustin, S. & Fell, D. (2015). Wood as a Restorative Material in Health-care Environments. URL: https://fpinnovations.ca/media/publications/documents/health-report.pdf

An Environmental Product Declaration (EPD) of PLC (Contempra) has been registered by the Cement Association of Canada with the CSA Group. This contributes to LEED v4 MRc Building Product Disclosure and Optimization – Environmental Product Declarations.

Vancouver Convention Centre, Vancouver, B.C. A LEED Platinum building with interior wood finishes (Image Courtesy of www.naturallywood.com).

Canadian PLC is structurally equivalent to ordinary Portland cement with a 10% reduction in embodied carbon.

2.3 Portland-limestone Cement (PLC)

The cement industry is a carbon intensive industry accounting for roughly 5% of the world's human-made CO_2 emissions. PLC (branded in Canada as Contempra[40]) is produced by intergrinding regular Portland cement clinker with 6%-15% limestone. Production of Portland cement clinker accounts for the majority of CO_2 emissions in the cement manufacturing process. Limestone added to the clinker in the production of PLC reduces the clinker content in the resulting cement, which therefore contains less embodied carbon.

Prior to 2011, limestone content was restricted to 5% in Canada; this was increased to a maximum of 15% limestone with the addition of PLC to the CSA C3001 *Cementitious Materials Compendium*[41]

Portland-limestone cement was used in the construction of the LEED Platinum Metrotower III in Burnaby, B.C. (Image courtesy of © Ledcor. All rights reserved).

40 Cement Association of Canada (2016). Contempra (Portland-Limestone Cement): A New Lower Carbon Cement. Cement Association of Canada (CAC) website. URL: http://www.cement.ca/en/Manufacturing/Contempra-Portland-Limestone-Cement-A-New-Environmentally-Friendly-Cement-Type.html

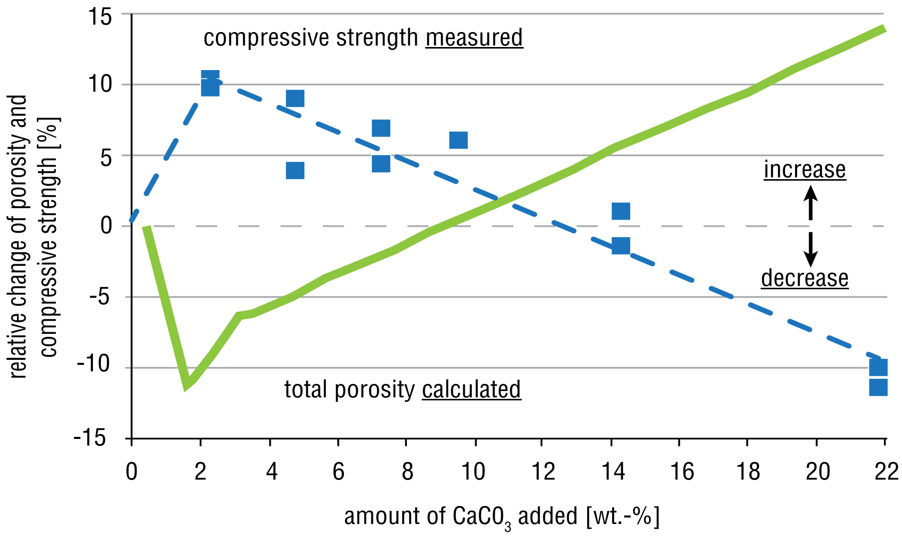
41 CSA (2013). Cementitious Material Compendium. CSA C3001-13. Mississauga, ON: Canadian Standards Association (CSA).

Table 1: General guidelines for the use of Portland cement and Portland-Limestone Cement

Name	Portland Cement	Portland-Limestone Cement	Application
General use hydraulic cement	GU	GUL	For use in general construction when the special properties of the other types are not required.
High-early-strength hydraulic cement	HE	HEL	For use when high-early-strength is required.
Moderate suphate- resistant hydraulic cement	MS	-	For use in general concrete construction exposed to moderate sulphate action.
High sulphate-resistant hydraulic cement	HS	-	For use when high sulphate resistence is required.
Moderate heat of hydration hydraulic cement	MH	MHL	For use in general concrete construction when moderate heat of hydration is required.
Low heat hydration hydraulic cement	LH	LHL	For use when low heat of hydration is required.

Types of hydraulic cement allowed in CSA A23.1-09. The restriction in note (2) was relaxed in the 2014 update to allow for the use of Portland-Limestone cement in sulphate environments.

Figure 2: Influence of limestone addition on porosity and strength of resulting concrete. (Matschei et al, 2007)



in 2008 and to CSA A23.1 *Concrete Materials and Methods of Concrete Construction*[42] in 2009. The 15% level was selected based on European experience and Canadian testing to provide a product that is structurally equivalent to ordinary Portland cement with a 10% reduction in embodied carbon.

The addition of less than 15% limestone does not affect the material properties of the resulting concrete. During hydration, the limestone reacts with aluminates in the clinker to produce carboaluminates, which decrease the porosity of the concrete and increase the strength.

This effect accounts for the losses from reduced clinker content[43]. As a result, PLC in Canada is equivalent in strength with regular Portland cement.

When first released in Canada, PLC was restricted from use in environments with sulphate exposure. Subsequent testing has shown positive results for PLC in such soil conditions and has expanded the use of PLC subject to the requirements outlined in CSA A23.1[44]. PLC is available in B.C. from LafargeHolcim and Lehigh Hanson Canada.

42 CSA (2014). Cement Materials and Methods of Concrete Construction. CSA A23.1-14. Mississauga, ON: Canadian Standards Association (CSA).

43 Matschei, T., Herfort, D., Lothenbach, B., and Glasser, F.P. (2007). Relationships of Cement Paste Mineralogy to Porosity and Mechanical Properties. In Proceedings of the Modelling of Heterogeneous Materials (MHM) with Applications in Construction and Biomedical Engineering. Prague, CZ. June 25-27, 2007, p. 262-263.

44 Cement Association of Canada (2016). Contempra (Portland-Limestone Cement): A New Lower Carbon Cement. Cement Association of Canada (CAC) website. URL: http://www.cement.ca/en/Manufacturing/Contempra-Portland-Limestone-Cement-A-New-Environmentally-Friendly-Cement-Type.html

Portland-limestone cement was used in the construction of TELUS Garden in Vancouver. The dramatic entrance features a sweeping roof with curved glulam beams (Image courtesy of Henriquez Partners Architects).

The City of Vancouver has adopted PLC for use in some infrastructure applications including sidewalks and gutters.

2.4 Other low carbon building materials

The VanDusen Botanical Garden Visitor Centre uses low-carbon building materials such as wood and stabilized rammed earth (Image Courtesy of Sirewall[49]).

The Wales Institute for Sustainable Education building at the Centre for Alternative Technology in Machynlleth, United Kingdom, uses many low carbon building materials including a 7.2 metre cement stabilized rammed earth wall, Forest Stewardship Certified (FSC®) glulam timbers, and hempcrete (Image courtesy of Russ Hamer).

Beyond wood and PLC, there are many other low carbon building materials that can be used in the commercial and institutional building industry in Canada. These materials can be found in commercial and institutional buildings in other areas around the world, including Europe, and are able to perform well architecturally, structurally, and often have a high energy performance and low embodied carbon. Five low carbon building materials that are being used more frequently due to the associated environmental and health benefits will be reviewed in this section.[46]

Supplementary Cementitious Materials

Portland cement clinker use may be reduced with the use supplementary cementitious materials (SCM). As many types of SCMs are waste products from other industries, their use in concrete mixes may contribute toward the targeting of the following LEED credits:

- MRc Building Life-Cycle Impact Reduction[47]
- MRc Building Product Disclosure Optimization – Sourcing of Raw Materials

Typical SCMs include fly ash, ground granulated blast furnace slag (GGBFS), and silica fume, which may be incorporated through intergrinding with cement clinker or added during concrete mixing. Resources for the specification and use of SCMs in concrete are provided by the Cement Association of Canada (CAC)[48] and the Portland Cement Association (PCA).[49]

Fly ash is produced from the combustion of coal at coal-fired power generation facilities and has been used in concrete since the 1930s.[50] The behavior of fly ash in concrete is most dependent on the calcium content; specification in Canada in CSA A3001 *Cementitious Materials for Use in Concrete* separates fly ash into three types: F, CI, and CH. Generally, well-proportioned concrete with fly ash is associated with a reduction in water use, improved workability, reduced bleeding and segregation, decreased air entrainment, and increased setting time.

45 http://trimtab.living-future.org/case-study/vandusen-botanical-garden-visitor-centre
46 https://www.architectural-review.com/today/wales-institute-for-sustainable-education-by-david-lea-and-pat-borer-machynlleth-wales-uk/8609396.article
47 http://cwc.ca/wp-content/uploads/2013/11/LEED-Case-Study.pdf
48 Cement Associate of Canada (CAC). Ottawa, ON. URL: www.cement.ca
49 Portland Cement Association (PCA). Skokie, IL. Website: www.cement.org
50 Thomas, M. (2007). Optimizing the Use of Fly Ash in Concrete. Report IS548. Portland Cement Association (PCA). Skokie, IL.

GGBFS is a by-product produced from the processing of iron ore to produce steel. Type S GGBFS may be used with up to 70% cement replacement, typically resulting in improved workability, shorter set time, higher strength, and improved resistance to sulphate attack.[51] Further information on GGBFS may be found through the Slag Cement Association.[52]

Silica fume is a byproduct from the production of silicon and ferro-silicon alloys. Silica fume is a highly effective pozzolan that is used to produce high-strength concrete. Further information may be found through the Silica Fume Association.[53]

Rammed Earth

Earth is one of the most commonly used and oldest building materials. In recent years, there has been a renewed interest in Europe and North America to earth as a building material in modern construction. Using rammed earth as a building material, popularized by the French[54] in the late 1800s, has become so popular in certain areas that building codes specifically focused on earthen materials have appeared, such as the New Mexico Earthen Building Materials Code.[55]

Structural Insulated Rammed Earth is a structural sandwich wall system typically 18” to 24” thick[56]. It uses local soil combined with 6%-10% cement compacted on either side of a hidden insulation core. This system has seen many applications in Canada and the United States. While the system had not yet been tested with PLC at the time of writing, it can be combined with local soil to achieve similar results. The system is stabilized with compacted earth and rebar to address seismic conditions. This high performance wall also provides thermal mass and efficiency with a distinctive, visceral connection to the earth without the need for additional sealants, siding or drywall. When choosing rammed earth as a building material, it is important to consider depth of experience and proven protocols to achieve consistent overall strength and durability.

Using SCMs in projects can also contribute to the following LEED credits:

- MRc Building Life-Cycle Impact Reduction
- MRc Building Product and Optimization (BPDO) –Environmental Product Declarations
- MRc BPDO – Sourcing of Raw Materials
- MRc BPDO – Material Ingredients; and RPc Regional Priority
- MRc Building Life-Cycle Impact Reduction (all of B.C.).

Nk’Mip Desert Cultural Centre, Osoyoos, B.C. (Image courtesy of Sirewall).

51 Slag Cement Association (2013). *Slag Cement and Fly Ash*. Publication No. 11. Slag Cement Association (SCA). Farmington Hills, MI.
52 Slag Cement Association (SCA). Farmington Hills, MI. URL: www.slagcement.org
53 Silica Fume Association (SFA). Lovettsville, VA. URL: www.silicafume.org
54 French Rammed Earth (n.d.). URL: http://rammedearthconsulting.com/rammed-earth-france.htm
55 New Mexico Earthen Building Materials Code (2015).
56 Sirewall: Structural Insulated Rammed Earth (2016). URL: http://sirewall.com

The structural block uses the natural insulating hurd material from the industrial hemp plant.

Biofiber

Biofiber is a high performance modular block wall system with a negative carbon material classification.[57] It can replace concrete blocks/panels/insulated concrete forms or a multi-component wood-frame construction with a simple inter-locking structural building block system. There is also a closely associated hemp lime material called hempcrete. It can be used in a number of building typologies, including institutional projects, offering fast construction with high insulation qualities and load bearing capacity.

It can be used in a variety of applications including but not limited to institutional applications. It achieves high insulation values (up to R40), thermal retention and 100% thermal break, as well as sound attenuation, increased durability, fire resistance and mold resistance.

The structural block uses the natural insulating hurd material from the industrial hemp plant. This biological plant fiber removes carbon dioxide from the air while it grows. The hemp lime block uses a binder that reclaims CO_2 released in its production. As a result of reduced energy input during its extraction and processing / manufacture and transportation combined with the materials ability to sequester carbon, Biofibre subsequently has a negative CO_2 emission rating.

57 Just Biofiber Structural Solutions (2014). URL: http://justbiofiber.ca/

Straw bale

Straw bale construction uses bales of straw from wheat, oats or barley that are then covered in plaster.[58] Straw is a low carbon building material and is typically considered a waste product by farmers, who often burn off what they cannot sell for animal bedding or landscaping. The burning creates air quality problems and GHG emissions.

Straw bale construction can be combined with other construction methods such as nail laminated posts or timber frame to support the roof. When built without timber-frame, the walls have to be compacted with steel cables and a ladder-like, wood structure must be added to the top course of bales to which roof trusses can be secured. Various types of straw bale construction exist, including prefabricated straw bale panels and traditional straw bales. Although often related to residential applications only, examples of commercial and institutional buildings exist, notably in the United Kingdom. The Alternative Village at the University of Manitoba in Winnipeg[59] has been researching and testing this method of construction, as well as others, through industry partnerships for approximately 15 years.

58 Sutton, A., Black, D., & Walker, P. (2011). Straw Bale. URL: https://www.bre.co.uk/filelibrary/pdf/projects/low_impact_materials/IP15_11.pdf

59 Straw Bale Research at the University of Manitoba (n.d.). URL: http://www.arch.umanitoba.ca/greenmap/pages/GM_oj%26tp_strawbaleUM%20/index.html

Just Bio Fiber blocks (Image courtesy of Just Biofiber).

Straw bale Research Building, University of Manitoba, Winnipeg, Manitoba. (Image courtesy of University of Manitoba).

Hempcrete

Similar to Biofiber, Hempcrete (or Hemplime) is a bio-composite material made of the inner woody core of the hemp plant mixed with a lime-based binder. The hemp core or "Shiv" has a high silica content which allows it to bind well with lime. This property is unique to hemp among all natural fibers. It lacks the brittleness of concrete and consequently does not need expansion joints. The result is a lightweight insulating material ideal for most climates as it combines insulation and thermal mass and can even be used in foundations, pipes or as plaster and floor slabs. Hempcrete can also be used in combination with hemp bales in a technique similar to straw bale construction.

The typical compressive strength of hempcrete is around 1 MPa, around 1/20 that of residential grade concrete. It is a low density material and resistant to cracking under movement thus making it highly suitable for use in earthquake-prone areas. Hempcrete walls must be used together with a frame of another material that supports the vertical load in building construction, as hempcrete's density is 15% that of traditional concrete.[61]

60 Modcell (2017). URL: http://www.modcell.com/projects/knowle-west-media-centre/

61 Flahiff, Daniel (August 24, 2009). "Hemcrete®: Carbon Negative Hemp

Hempcrete is a low density material and resistant to cracking under movement thus making it highly suitable for use in earthquake-prone areas.

Knowle West Media Centre, Bristol, UK, using ModCell prefabricated straw bale panels (Image courtesy of ModCell).


L'École Mer et Montagne, Campbell River (Photo: Derek Lepper)

Comprehensive Guide
LEED v4 and Low Carbon Building Materials

3.0 Leadership in Energy and Environmental Design (LEED)

3.0 Leadership in Energy and Environmental Design (LEED)

The B.C. Cancer Research Centre in Vancouver was one of the first LEED Canada certified projects, achieving LEED Gold certification in 2005. (Image courtesy of IBI Group/Henriquez Partners Architects in Joint Venture. Photographer: Nic Lehoux).

Operations Centre, Gulf Islands National Park Reserve, Sidney, B.C. was the first project to be awarded LEED Platinum in B.C. (2006) (Image courtesy of McFarland Marceau Architects Ltd. and Willie Perez, P. Eng.).

The LEED green building rating system has been on the North American market for almost 20 years. In 1998, the USGBC released the first pilot version of LEED for New Construction (NC). In 2004 the system was adopted and adapted for the Canadian market, and as of February 2017, over 6,000 projects have been registered and certified in Canada, accounting for over 63 million gross square metres of certified and registered space.

Globally, LEED has been used in over 160 countries worldwide; the top countries with the highest number of LEED certified buildings outside the US, includes: Canada, China, India, and Brazil. The US far exceeds all other countries with 27,699 LEED projects culminating in 336.84 gross million square metres; figures were reported by the USGBC as of December 14, 2016. As of 2017, B.C. had the highest number of LEED Gold and Platinum provincial public sector buildings in Canada, with almost 40% the national total.

Originally designed for NC buildings only, LEED has expanded over the last decade to five rating systems that serve different project types and scales.

LEED Project Types
Building Design + Construction
Building Operations and Maintenance
Interior Design and Construction
Neighborhood Development
Homes

Based on: LEED Project Types
(ref: http://www.usgbc.org/leed)

Walls". Inhabitat.

LEED certification levels are based on minimum point thresholds. Although LEED rating system points thresholds have traditionally varied, they have now been standardized as noted below.

LEED Certification	Points Threshold
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80+

LEED in Canada

In 2002, the CaGBC was formed to advance green buildings in Canada, and in 2004, subsequently released the first version of LEED Canada for NC. From 2004 - 2009 the CaGBC adapted other Canadian-specific versions of LEED from the original USGBC versions; these rating systems addressed homes, commercial interiors, existing buildings and neighbourhood developments.

The USGBC first announced the release of LEED v4 in 2013. Rather than continue to develop country specific rating systems, the new direction for international LEED projects was to follow the US LEED system, which includes country-specific guidance for specific credits, in the form of Alternative Compliance Paths (ACPs). As of November 1, 2016 all newly registered LEED projects must register under LEED v4 and document credit achievement through LEED Online.

Major Changes from LEED 2009

The release of LEED v4 introduced the most substantial changes the rating system has seen to date. These include administrative, format, and content changes, which are described below.

Administrative Changes

LEED v4, unlike previous versions of LEED in Canada, is administered by the USGBC and certified by the Green Business Certification Inc. (GBCI). Recently, the CaGBC and USGBC have collaborated to ensure Canadian projects can register through LEED Online, further simplifying registration. LEED Online is an intuitive online platform which allows project team members to easily upload submittals and fill out online forms, and supports design and construction reviews, as well as appeals, should they be desired by the project team.

Gibsons Elementary School, LEED Canada 2009, Gold certified (Image courtesy of Ed White/KMBR).

Table 2: Major events in the development of LEED in Canada.

Event	Date
Formation of CaGBC	2002
LEED Canada NC v1.0 is released	2004
LEED Canada Commercial Interiors (CI) v1.0 is released	2006
First major addendum to LEED Canada NCv1.0	2007
LEED Canada Existing Buildings: Operations & Maintenance (EB:OM) 2009 is released	2009
LEED Canada NC 2009 is released	2010
LEED v4 is launched by the USGBC	2013
LEEDv4 is required for all newly registered projects.	November 1, 2016

LEED v4 has undergone several major format changes, the most relevant being that two new credit categories were created... Integrative Process (IP) and Location and Transportation (LT).

For international projects, such as projects in Canada, the USGBC has developed country-specific ACPs. As of February 2017, six ACPs have been approved for Canadian projects targeting LEED v4 BD+C:

- LEED BD+C – LT, Sensitive Land Protection
- LEED BD+C Healthcare – SS, Places of Respite
- LEED BD+C – EA, Optimize Energy Performance
- LEED BD+C – MR, Legal Wood
- LEED BD+C Healthcare – EQ, Minimum IAQ Performance
- LEED BD+C Healthcare – EQ, Construction Indoor Air Quality Management Plan

Major Format Changes

LEED v4 has undergone several major format changes, the most relevant being that two new credit categories were created:

- Integrative Process (IP)
- Location and Transportation (LT)

IP looks to ensure that projects are using an integrated design approach, and requires pre-schematic design energy and water consumption analysis for the building and the site. LT has adopted several credits originally included in the Sustainable Sites category and has added additional credits such as LEED for Neighborhood Development Location and High Priority Site.

LEED 2009 saw seven minimum program requirements (MPRs) that have either been combined, added to a credit or a prerequisite, or removed completely for LEED v4, which now has three MPRs. MPRs are the rating system's base minimum requirements; all projects must achieve the three MPRs to be eligible to pursue LEED certification.

Credit Categories in LEED v4

Integrative Process *(new)*
Location and Transportation *(new)*
Sustainable Sites
Water Efficiency
Energy and Atmosphere
Materials and Resources
Indoor Environmental Quality
Innovation in Design
Regional Priority

Minimum program requirements in LEED v4.

1. Must be in a permanent location on existing land.
2. Must use reasonable LEED boundaries.
3. Must comply with project size requirements.


Detail at Wood Innovation & Design Centre in Prince George, B.C.. (Photo Ed White).

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LEED v4 and Low Carbon Building Materials

4.0 Detailed review of how low carbon materials earn credits under LEED v4

4.0 Detailed review of how low carbon materials earn credits under LEED v4

This section will describe the nine LEED BD+C credits to which low carbon building materials, such as wood and PLC, can directly contribute.

LEED BD+C prerequisites and credits may be affected by choosing low carbon building materials. For example, using wood studs can reduce thermal breaks, which will support a more energy efficient design, and wood finishes may positively contribute to acoustic performance. Using PLC in paving and other site specific materials, although not rewarded by LEED credits, will also contribute to a lower embodied carbon footprint of a development.

Table 3: Low carbon building materials and relevant LEED credits.

Category	Credit	Maximum Points
Materials and Resources	Building Life-Cycle Impact Reduction	5
	Building Product Disclosure and Optimization - Environmental Product Declarations	2
	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
	Building Product Disclosure and Optimization - Material Ingredients	2
	Furniture and Medical Furnishings (Healthcare Only)	2
Indoor Environ-mental Quality	Low Emitting Materials	3
	Indoor Air Quality Assessment	2
Innovation	Innovation	5
Regional Priority	Regional Priority – MRc Building Life-Cycle Impact Reduction (all regions of B.C.)	1 - Bonus Point

Since LEED 2009, up to four points are available to projects under a category titled Regional Priority. Points are awarded based on the project's achievement of one or more predetermined LEED credits identified by the CaGBC or USGBC as a regional priority for the project's location. For B.C., and in the context of low carbon materials, the relevent Regional Priority credit is "Building Life Cycle Impact Reduction."

Materials and Resources

The LEED BD+C v4 Materials and Resources category primarily focuses on how building materials used in the construction and operation of buildings can impact the environment. Using low carbon materials can directly contribute towards satisfying four LEED v4 credits.

Materials and Resources Credit: Building Life-Cycle Impact Reduction

Possible points for BD+C: 2-5

Intent

To encourage adaptive reuse and optimize the environmental performance of products and materials[62].

Requirements

This credit focuses on reducing the environmental impacts of new buildings by encouraging the reuse of historic, blighted or abandoned buildings (with minimum surface area retention thresholds), or through the use of salvaged structural materials, or through the use of whole building life-cycle assessment. Each option presents minimum thresholds for achievement, and all options are linked to pre-schematic design project decision-making. For the purposes of this Guide, we have focused on Option 4: Whole Building Life Cycle Assessment.

This credit's four options are summarized on the right side of this page.

Description

This credit considers the environmental impact of a building's structure and enclosure over its entire lifecycle, from cradle to grave. Life Cycle Assessment (LCA) has been largely overlooked in previous versions of LEED, and this credit now offers a whole building LCA option, with a mandatory 10% threshold reduction in at least three of the following six predetermined impact categories:

- Global warming potential (ie. GHG emissions): this threshold is mandatory for all projects undertaking this credit,
- Depletion of stratospheric ozone,
- Acidification of land and water sources,
- Eutrophication,
- Formation of tropospheric ozone
- Depletion of non-renewable energy sources.

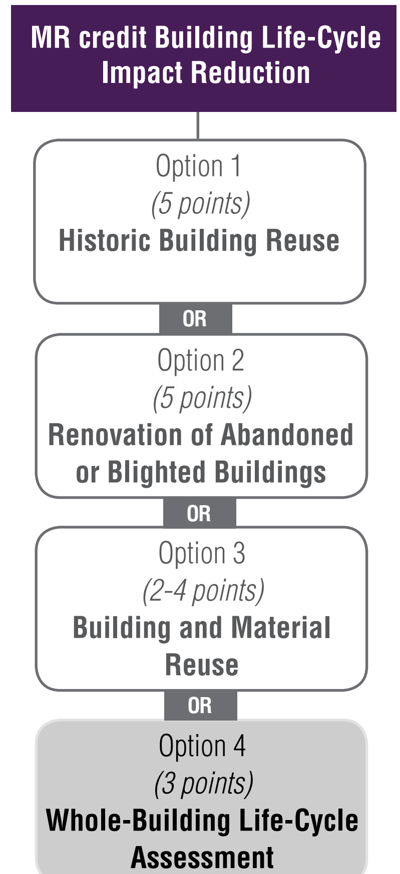
Considering the overall lifecycle impact of a project's structural materials can help reduce a building's embodied carbon and other environmental impacts.

Tips for achieving this credit:

- Use an LCA calculator, such as the Athena Institute's Impact Estimator[63], that has an extensive product catalogue and includes material data for wood products and Canadian PLC.
- Create a baseline model early during schematic design. Use the baseline model to compare with proposed design decisions with input from the design team. Update baseline and proposed models accordingly throughout the design.

62 LEED v4 BD+C Reference Guide page 495

63 Athena Sustainable Materials Institute (2017). URL: http://www.athenasmi.org/



- Combine early LCA outputs with early energy modelling for performance-based design approach. Consider also coordinating with other disciplines such as building envelope consultant to inform design.

Changes from LEED 2009

This credit has combined two LEED 2009 credits: MRc1.1 and MRc1.2 Building Reuse, and also added new options. The Option 4 life-cycle impact assessment option is a new requirement which was not previously available under LEED v2009.

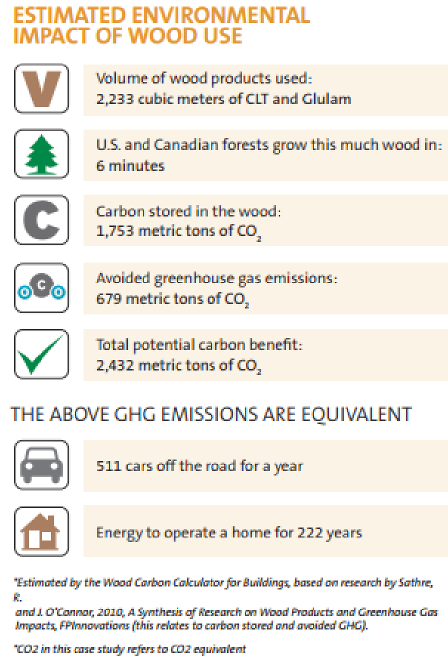


Image courtesy of Naturally:Wood.

The new Brock Commons Tall Wood House student residence at the University of British Columbia in Vancouver features 17-storeys of timber structure over a single concrete level. A whole building life-cycle analysis was undertaken on the building.
(Image courtesy of www.naturallywood.com).

Materials and Resources Credit: Building Product Disclosure and Optimization - Environmental Product Declarations

Possible points for BD+C: 1-2

Intent

- To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts.
- To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.[64]

Requirements

This credit rewards manufacturer transparency, regional manufacturing, and emissions reductions. Products with an ISO compliant, generic industry or Type III product-specific environmental product declaration (EPD), contribute to this credit through Option 1.

This credit also rewards manufacturers, through Option 2, who demonstrate impact reductions below industry standard in at least three of six predetermined impact categories; the same impact categories noted in the MR: Building Life-Cycle Impact Reduction credit. Additional credit is given to products with a total life cycle, (extracted, manufactured, purchased, installed), completed within 100 miles or 160 km of the project site; this approach uses a multiplier effect, valuing regional products with impact reductions at 200% of their material cost to the project. Note: Only 30% of structure and enclosure materials, by cost, are allowed to be counted towards Option 2 for this credit.

64 LEED v4 BD+C Reference Guide page 513

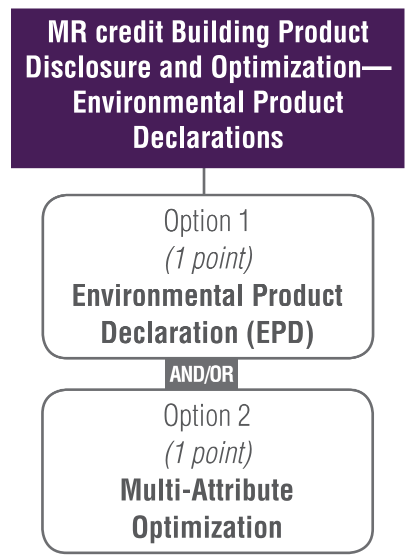
This credit's options are summarized on the right side of this page.

Description

This credit focuses greater consumer attention on manufacturer disclosure, standardizes disclosure reporting, and encourages widespread manufacturer disclosure of emissions across many product types and applications. Option 1 distinguishes between generic industry EPDs and product-specific EPDs, by valuing product-specific EPDs as 1 product; generic industry EPDs are valued at 0.5 of a product. In order to achieve the requirement of 20 product-specific EPDs from a minimum of five manufacturers, it is likely that project teams will focus on the specification of products with product-specific EPDs over generic industry EPDs. This presents an excellent opportunity for manufacturers of low-carbon materials to focus their efforts in this area.

Regional manufacturers who demonstrate impact reductions in a minimum of three of the six predetermined impact categories also receive a value multiplier effect, as noted in the Requirements section above. This multiplier presents an excellent opportunity for regional manufacturers of low-carbon materials to innovate, and establish regular reporting, through EPDs and corporate social responsibility (CSR) frameworks, which demonstrate their impact reductions.

Note: EPDs are one standardized way of communicating the environmental effects associated with a product or system's raw material extraction, energy use, chemical makeup, waste generation, and emissions to air, soil, and water. It is important to note



A large list of products with EPDs can be found at ICC Evaluation Service: http://www.icc-es.org/ep/epd-directory.shtml. A list of wood related EPDs can also be found at Canadian Wood Council: http://cwc.ca/green/epds/.

that before EPDs can be created for a given industry, Product Category Rules (PCRs) must first be written and approved by a third-party to provide a standardized format for the industry's EPD. PCRs are typically created by Program Operators, who also offer third-party EPD approval, however it is possible for industry to collaborate with Program Operators to create PCRs. Well known North American Program Operators include:

- ASTM
- FPInnovations
- NSF International
- SCS Global Services
- UL Environment

Several of these Program Operators have recently formed the Program Operator Consortium, to increase PCR and EPD standardization, and delivering education to industry on expiring PCRs, verifying EPDs and LCA reports, and providing access to a North American catalogue of PCRs and EPDs.

Tips for achieving this credit

- During schematic design, identify typical structural and finishing material types which have product-specific versus general industry EPDs. If in doubt, consult public lists of PCRs, which will indicate the product type's level of regulation.
    - At the time of writing, the following product types had PCRs approved by UL Environment[65]:
        - Bg Metals
        - Curtain Wall
        - Engineered Stone
        - Non-Metal Ceiling Panels
        - Paints and Varnishes
        - Flooring
    - At the time of writing, the following product types had PCRs approved by FPInnovations[66]:
        - Architectural and Structural Wood Products
        - Gypsum Boards
    - At the time of writing, the following product types had PCRs approved by NSF International[67]:
        - BIFMA Office Furniture Workspace Products
        - Architectural Coatings
        - GANA Flat Glass
        - Residential Countertops
        - BIFMA Storage
        - Flooring: Carpet, Resilient, Laminate, Ceramic, Wood
        - BIFMA Seating
        - RCMA PCR for Roof Coatings
- Work with the architect and interior designer to identify products with EPDs, and update the finishes schedule to reflect these products.
- Consider a policy of not accepting substitutes for products with EPDs.
- Collect manufacturer EPDs during the design phase, for all EPD products specified on the finishes schedule.
- Provide detailed guidance on sourcing and provide documentation for EPDs in the architectural and/

65 Product Category Rules (2017). URL: http://industries.ul.com/environment/transparency/product-category-rules-pcrs

66 EPD Program (2017). FP Innovations. URL: https://fpinnovations.ca/ResearchProgram/environment-sustainability/epd-program/Pages/default.aspx

67 The Public Health and Safety Organization (2017). Product Category Rules. URL: http://www.nsf.org/services/by-industry/sustainability-environment/product-transparency-reports/product-category-rule

or interior design specifications and drawings.

- Review contractors' proposed substitutions during pre-tender or tender and approve based on EPD document submission.
- Ensure sub-contractors are briefed about EPDs and the project's substitution policy prior to product ordering.
- Require all sub-contractors to submit EPDs for specified product(s) prior to product ordering and installation on-site.
- Track all compliant products on-site.

Changes from LEED 2009

This is a new credit in LEEDv4.

Materials and Resources Credit: Building Product Disclosure and Optimization - Sourcing of Raw Materials

Possible points for BD+C: 1-2

Intent

- To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts.
- To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.[68]

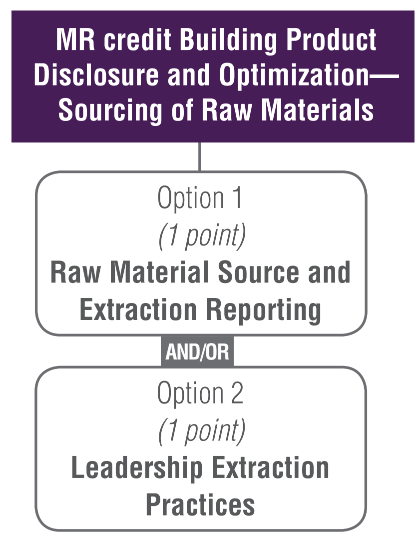
Requirements

This credit offers two compliance paths for product selection, which can be combined; wood and PLC products can contribute under both options. This credit's options are summarized on the right side of this page.

This credit rewards manufacturers with self-declared annual reporting (valued at 0.5 of a product), or annual reporting which meets third-party corporate social responsibility (CSR) frameworks, such as Global Reporting Initiative (GRI), Organization for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises, UN Global Compact and ISO 26000 (valued at 1 product). The goal is to source 20 products from 5 different manufacturers which meet one of the disclosure criteria (Option 1); if products also meet criteria outlined under Option 2, an additional point is awarded.

This credit also rewards products having manufacturer compliance with at least one of the following practices which reduce extraction-related impacts (Option 2):

- Take back programs of consumer products at end of life, known as extended producer responsibility (EPR).
- Incorporation of bio-based materials, which comply with Sustainable Agriculture Network's Sustainable Agriculture Standard (SAN); includes agricultural and forestry products.
- Wood or wood-alternative products such as bamboo, strawboard, or wheatboard, which comply with Forest Stewardship Council (FSC) certification or a USGBC-approved equivalent.
- Incorporation of reused, or salvaged, materials or components.
- Incorporation of recycled content, where post-consumer content is given full value, and pre-consumer is given 0.5 value.



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LEGAL WOOD ACP

ASTM D7612-10 (2015) DEFINES LEGAL SOURCES AS:

- Fiber from jurisdictions with a low risk of illegal activity, or from controlled wood, stair-step, legality assessments, or other proprietary standards.
- Forest certification or management standards must be governed by public legislation, or regulatory processes, or consensus-based.
- Required documents must show traceability to the applicable jurisdiction.

ASTM D7612-10 (2015) DEFINES RESPONSIBLE SOURCES AS:

- Meeting all requirements under Legal Sources, and
- Allowing proprietary standard governance in place of public legislative or consensus-based governance; and
- Requiring traceability by a certified procurement system, or chain of custody system, in place of traceability to the applicable jurisdiction; and
- Requiring compliance for water quality protection best management practices; or
- Forest Management Plans in substantial compliance with Guide D7480-08 or equivalent.

Table 4: Certified Wood Acceptable for LEED MR Legal Wood ACP[1].

	Program	Legal	Responsible	Certified
1	FSC - forest management via FSC chain of custody	Yes	Yes	Yes
2	FSC - controlled wood	Yes	No	No
3	SFI - forest management via SFI or PEFC chain of custody	Yes	Yes	Yes
4	SFI - fiber sourcing	Yes	Yes	No
5	ATFS - forest management via SFI or PEFC chain of custody	Yes	Yes	Yes
6	CSA - forest management via SFI or PEFC chain of custody	Yes	Yes	Yes
7	PEFC - forest management via PEFC chain of custody	Yes	Yes	Yes
8	PEFC - due diligence	Yes	No	No
9	Not certified	No	No	No

USGBC Legal Wood Pilot ACP Calculator (2016). URL: http://www.usgbc.org/resources/legal-wood-pilot-acp-calculator

- Products with a total life cycle, (extracted, manufactured, purchased, installed), within 100 miles or 160 km of the project site; this approach uses a multiplier effect, valuing regional products with impact reductions at 200% of their material cost to the project. Note: Only 30% of structure and enclosure materials, by cost, are allowed to be counted towards Option 2 for this credit.

The goal is to source 25% of products, by cost, which meet the above criteria, as a percentage of the total permanently installed products, by cost, on the project.

Legal Wood: A Pilot Alternative Compliance Path

At the time of writing, USGBC was offering a Pilot Alternative Compliance Path (ACP) titled Legal Wood. This Pilot ACP rewards manufacturer products under Option 2, and has its own set of criteria.

Chain of custody systems such as American Tree Farm System (ATFS), Canadian Standards Association (CSA), FSC, Programme for the Endorsement of Forest Certification (PEFC), and Sustainable Forestry Initiative (SFI) certification would all meet the traceability requirement noted under Responsible Sources in the sidebar.

Description

The extraction of raw materials directly impacts ecosystems, and therefore this credit encourages manufacturers to move towards, or expand upon existing, responsible extraction practices.

Table 5: Effect of cement replacement with fly ash on embodied carbon of concrete.

Concrete Grade	Embodied Carbon (kg CO_2-e/kg) Cement Replacement with Fly Ash (%)		
	0%	15%	30%
RC 20/25 (20/25 MPa)	0.132	0.122	0.108
RC 25/30 (25/30 MPa)	0.140	0.130	0.115
RC 28/35 (28/35 MPa)	0.148	0.138	0.124
RC 32/40 (32/40 MPa)	0.163	0.152	0.136
RC 40/50 (40/50 MPa)	0.188	0.174	0.155

In this credit, wood products can contribute under both Options 1 and 2. Under Option 2, it is possible for all types of wood products, including composite wood, and alternative-wood products to satisfy the credit requirement to meet at least one of the following:

- To comply with Extended Producer Responsibility (EPR) requirements,
- To comply with FSC or USGBC equivalent certification,
- To meet regional manufacturing and harvesting requirements,
- To comply with the Pilot ACP Legal Wood requirements.

Under Option 2, it is also possible for composite, and alternative, wood products:

- To comply with recycled content requirements;
- To comply with reuse or salvaged requirements, although this is far rarer than recycled content.

In this credit, PLC products can contribute under both Options 1 and 2. Under Option 2, it is possible for PLC products to satisfy the credit requirements to meet at least one fo the following:

- To comply with EPR requirements,
- To comply with recycled content requirements,
- To meet regional manufacturing and harvesting requirements.

Reducing the amount of raw material extraction can also reduce a project's overall carbon intensity. For example, a recent study compiled data looking at the embodied carbon reduction in concrete that uses various levels of flyash. Flyash is a by-product of the coal industry and is commonly specified in LEED projects as a supplementary cementitious material (SCM). Using flyash in concrete has several benefits, including reducing embodied carbon and using an otherwise waste product and diverting it from a landfill.

Tips for achieving this credit

- During schematic design, identify typical structural and finishing products which either comply with one or more of Option 2 requirements OR whose manufacturers have third party verified CSR reports which comply with one of the Option 1 requirements.
  - At the time of writing, the most infrequently seen third-party CSR report frameworks were:
    - OECD Guidelines for Multinational Enterprises.
    - UN Global Compact.
  - At the time of writing, the most difficult Option 2 criteria included:
    - SAN-certified bio-based materials.
    - Salvaged, refurbished or reused products.
    - Products which met all aspects of the regional extraction, manufacturing and purchasing criteria.
- Provide detailed guidance on sourcing and documentation in the architectural and/or interior design specifications and drawings.

69 Akbarnezhad, A. (2017). Estimation and Minimization of Embodied Carbon of Buildings: A Review URL: www.mdpi.com/2075-5309/7/1/5/pdf

- During the investigation process, populate the materials tracker with compliant materials and estimated costs per owner or contractor expectations, and compile a database of compliant products for future projects.[70]
- Consider a no-substitution policy for compliant products.
  - Collect manufacturer documentation during the design phase.[71]
- Review contractors' proposed substitutions during pre-tender or tender and approve based on product document submission.
- Confirm details about each type of compliant documentation and the project's substitution policy prior to product ordering.
- Require all sub-contractors to submit compliant documentation for specified products prior to product ordering and installation on-site.
- Track all compliant products on-site.

70 Forest Products Association of Canada (n.d.). Certification Map of Canada. URL: http://certificationcanada.org/index.php/maps-en/provincial/bc
71 Ecotrust Canada.

Changes from LEED 2009

This credit combines the criteria of the following LEED v2009 MR credits:

- MRc1 Materials Reuse
- MRc4 Recycled Content
- MRc5 Regional Materials
- MRc6 Rapidly Renewable Materials
- MRc7 Certified Wood.

In B.C., there are 52 million hectares of forests certified to one of three internationally recognized forest standards.

RAPIDLY RENEWABLE MATERIALS

In previous versions of LEED, rapidly renewable materials were defined as materials with a harvest cycle of 10 years or less (LEED Canada 2009, p. 424); typical materials include bamboo, straw, wheat, cotton, and hemp. LEED v4 has adjusted compliance requirements for rapidly renewable materials, and now requires that non-wood, bio-based products meet Sustainable Agriculture Standard, as noted above under Option 2. An example of a bio-based product that falls within this category is biofiber, a pre-fabricated block system using hemp.

Materials and Resources Credit: Building Product Disclosure and Optimization - Material Ingredients

Possible points for BD+C: 1-2

Intent

- To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts.
- To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances.
- To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.

Requirements

This credit rewards manufacturers which publicly declare all product ingredients, using any recognized third-party frameworks or certifications (Option 1), and rewards project teams for selecting permanently installed products with these certifications (Options 2 and 3). Option 1 recognizes any of the following third party frameworks and certifications available to manufacturers:

- Publicly available inventory that lists the name and Chemical Abstract Service Registration Number (CASRN) of each ingredient.
- Health Product Declaration, compliant with the Health Product Declaration Open Standard 2.0.
- Cradle to Cradle (C2C) version 2 (v2) Basic Level, or v3 Bronze Level certification.

Under Option 2, project teams are rewarded for selecting products which, in total, make up 25% of the total material cost of all permanently installed products, and which meet any of the following third-party certifications:

- GreenScreen version 1.2 Benchmark; this certification offers a multiplier effect: value products at 100% of their cost if ingredients have gone through the GreenScreen Translator; value products at 200% of their cost if ingredients have gone through the GreenScreen Assessment.
- C2C certification; a multiplier effect is also available here: value products at 100% of their cost if they are C2C v2 Gold, or v3 Silver; value products at 200% of their cost if they are C2C v2 Platinum, or v3 Gold or Platinum.
- International Alternative Compliance Path – Registration, Evaluation, Authorisation and Restriction (REACH) Optimization: compliant if the product is free of ingredients classified under the REACH Authorization or Candidate List.
- ANSI/BIFMA e3 Furniture Sustainability Standard, with a minimum 3 points under 7.5.3.1 Advanced Level (e3-2014), or 3 points under 7.4.1.3 Advanced Level (e3-2012).

Under Option 3, project teams are rewarded for selecting products which, in total, make up 25% of the total material cost of all permanently installed products, made by manufacturers which comply with:

- Minimum safety, health, hazard and risk products which document 99%, by weight, of all product ingredients.
- Third party supply chain verification; verification is required for major processes related to health, safety and environmental impacts.

Option 3 offers additional credit to manufacturers which use GHS Category 2 criteria for ingredient hazard screening, rather than the default Category 1 criteria; hazard screening examines carcinogens, mutagens, reproductive toxins and skin irritants. The full list for this option is available through the USGBC.

This credit's options are summarized on the right side of this page.

Description

Manufacturers are currently not required to publicly disclose chemicals of concern, and for those manufacturers who do disclose chemical ingredients, disclosure of 99% of ingredients by weight is still rare. This credit's creation was influenced by recent research linking undeclared product ingredients to occupant health, and is part of the USGBC's drive towards greater manufacturer transparency, and increased awareness around occupant health.

This credit aims to support manufacturers which currently disclose ingredient information, and encourage others to move towards greater supply chain transparency, ultimately helping project teams to make better-informed product decisions.

Tips for achieving this credit

- During schematic design, identify typical structural and finishing products which either comply with the criteria of Options 1, 2 or 3.
- Provide detailed guidance on sourcing and documentation in the architectural and/or interior design specifications and drawings.
- During the investigation process, populate the materials tracker with compliant materials and estimated costs per owner or contractor expectations, and compile a database of compliant products for future projects.
- Consider a policy of not accepting substitutes for compliant products.
- Collect manufacturer documentation during design phase.
- Review contractors' proposed substitutions during pre-tender or tender and approve based on product document submission.
- Ensure sub-contractors are briefed about each type of compliant documentation and the project's substitution policy prior to product ordering.
- Require all sub-contractors to submit compliant documentation for specified products prior to product ordering and installation on-site.
- Track all compliant products on-site.

Changes from LEED 2009

This is a new credit in LEED v4.

MR credit Building Product Disclosure and Optimization—Materials Ingredients

Option 1
(1 point)
Material Ingredient Reporting

AND/OR

Option 2
(1 point)
Material Ingredient Optimization

AND/OR

Option 3
(1 point)
Product Manufacturer Supply Chain Optimization

Table 6: A Comparison of Manufacturer Inventory Frameworks

Framework Name	Managed By	Organization Type	Framework Description
GreenScreen Benchmark	Clean Production Action	Non-Profit Organization	• Scientific chemical hazard assessment, widely used by industry, government and NGOs • Transparent, freely available; sets out four clear benchmarks towards safer chemicals • Built on the 12 Principles of Green Chemistry and US Environmental Protection Agency (EPA)'s Design for the Environment (DfE) alternatives assessment method • Collates over 40 scientific lists of chemicals, allowing manufacturers to quickly search chemical lists to inform ingredient procurement
CASRN	American Chemical Society	Non – Profit Organization World's Larg-est Scientific Society	• Authoritative collection of disclosed chemicals: 129 million organic and inorganic substances (world's largest collection) and 67 million sequences • Covers substances named from 1957 – present • Internationally recognized • Quick and reliable validation of CAS Numbers • Widely used by industry and government • Member-based organization
C2C	Cradle to Cradle Products Innovation Institute	Non-Profit Organization	• Originally conceived as a mechanism for industry change • C2C Certified Product Standard assesses products on five categories: Material Health, Material Reutilization, Renewable Energy and Carbon Management, Water Stewardship and Social Fairness • C2C also offers a material health certificate

HPD	Health Product Declaration Collaborative	Non-Profit Organization	• Standard is a voluntary, stakeholder consensus standard with a Creative Commons license • Specification standard, aims to provide comprehensive info currently excluded from MSDS and EPDs • Industry can download and build their own HPD • Partnering with Healthy Building Network, Healthy Materials Lab and JPB Foundation to develop Healthy Affordable Materials Project (HAMP) • Member-based organization
REACH	European Union Regulation (December 18, 2006), administered by European Chemicals Agency (ECHA)	Government, includes a Member State Committee and Management Board	• Applies to all chemicals involved in industrial processes and consumer products • Manufacturers must register chemicals; evaluation is then completed • Very high concern substances are first added to the Candidate List, and eventually the Authorization List • Chemicals on the Authorization List trigger import, producer and supplier obligations and require downstream notification of the public

Materials and Resources Credit: Furniture and Medical Furnishings

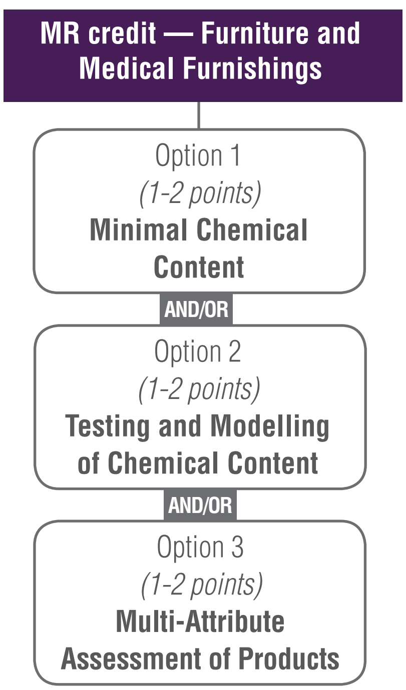
Possible points for BD+C, Healthcare Only: 1-2

Intent

To enhance the environmental and human health performance attributes associated with freestanding furniture and medical furnishings.[72]

Requirements

This credit sets a cost calculation threshold of 30% (1 point) or 40% (2 points), of the total free-standing furniture and medical furnishing cost, under Option 1, or Option 2, or Option 3 compliance paths. This credit rewards manufacturers which have reduced chemical content in their products (Option 1), or have reduced chemical content in their products, and comply with emissions testing ANSI/BIFMA e-2010 Furniture Sustainability Standard (Option 2), or select products with EPDs and extraction-related impact reductions (Option 3). This credit's three compliance options are summarized on the left side of this page.



Option 1 sets of a threshold of 100 parts per million (ppm) or less for four out of the five chemicals listed below, for any component which comprises 5%, or more, of the total weight of the product:

- Urea formaldehyde
- Heavy metals such as mercury, cadmium, lead and antimony
- Hexavalent chromium in plated finishes
- Stain and non-stick treatments derived from perfluorinated compounds (PFCs)
- Added antimicrobial treatments

Option 2 sets the same threshold as Option 1, for two out of the five chemicals listed, and requires compliance with the ANSI/BIFMA standard.

Option 3 requires compliance with at least one of the following:

- Product-specific LCA which complies with ISO 14044, or
- Product-specific (valued at one), or generic, industry-wide (valued at half), EPD, or
- Product which contains salvaged, refurbished or reused materials, or
- Product which contains either pre-consumer (valued at half), or post-consumer (valued at one), recycled content, or
- Manufacturer with consumer take-back program, or
- Product which contains bio-based materials compliance with SAN certification, or
- Product which contains FSC-certified wood material, or
- Product whose total extraction life-cycle, (extracted, manufactured, purchased, installed), is within 100 miles or 160 km of the project site (these products are valued at 200% of their base contributating cost).

Description

This credit includes soft medical furnishings such as: mattresses, foams, panel fabrics, cubicle curtains, windows coverings, and other textiles typically purchased by the project owner or operator. It is therefore critical to obtain early team support if this credit is targeted. This credit also includes medical furnishings such as:

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surgical tables, carts, lifting and transfer aids, shelving and overbed tables.

Tips for Achieving This Credit:

- During design, create a furniture and furnishings budget to determine the highest cost items, which could contribute to credit requirements.
- Research manufacturers with compliant products for the highest cost items, and obtain the necessary documentation during design.
- Provide detailed guidance on sourcing and documentation in the architectural and/or interior design specifications and drawings, and directly to the owner and/or furniture and furnishings procurement team.
- Consider a policy of not accepting substitutes for compliant products.
- Provide training to the owner and/or furniture and furnishings procurement team on each type of documentation and the project's substitution policy prior to pre-tender, tender and product ordering.
- Work closely with owner or furniture & furnishings procurement team in pre-tender and tender, to ensure that credit requirements are achievable and products are available.
- Review all products during pre-tender or tender and approve based on manufacturer document submission.
- Track all compliant products during ordering via a furniture and furnishings material tracker.
- Train sub-contractors on furniture and furnishings installation and the project's substitution policy, especially if VOC-containing products could be used during installation; track all associated VOC-containing products as part of the IEQ: Low Emitting Materials credit.

Changes from LEED 2009

- Points thresholds have been reduced from LEED 2009 to LEED v4.
- Emissions testing standard has been changed from the California Special Environmental Requirements Specifications Section 01350, to the ANSI/BIFMA standard.
- The LEED 2009 rapidly renewable criteria has been deleted, and replaced with the SAN standard for bio-based materials.
- The LEED 2009 radius for regional product extraction life-cycled has been reduced from 800 km by truck, or 2400 by ship/rail, to 160 km.
- LEED v4 has added EPR, LCA and EPD requirements.

Indoor Environmental Quality

The Indoor Environmental Quality (IEQ) category in LEED aims to address and improve indoor environmental conditions. Canadians spend an average of 90% each day indoors and indoor air, according to the U.S. Environmental Protection Agency, may be 2x-5x more polluted than outdoor air. It can occossionally be up to 100x more polluted for certain toxins. IEQ addresses air quality, lighting quality, daylighting, and visual, thermal and acoustic comfort. Products that happen to be low carbon, such as wood, may contribute and be relevant to LEED credits in this category.

Indoor Environmental Quality: Low-Emitting Materials

Possible points for BD+C: 1-3

Intent:

To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.[73]

Requirements:

This credit rewards manufacturers which meet low emissions standards, and rewards project teams under prescriptive compliance, for all products used on-site inside the weather proofing membrane (Option 1), or project teams which use the budget calculation method to demonstrate cumulative compliance (Option 2).

Under Option 1, project teams may choose the number of category thresholds with which to comply; for all BD+C project types without furniture, with the exception of Healthcare and Schools, a minimum of two category thresholds must be targeted to achieve one point; additional points require additional target thresholds. The same BD+C project types must target at least three category thresholds to achieve one point if their scope includes furniture; see table 7 below.

Table 7: BC+C Category Thresholds

BD+C Project Type Options	Category Thresholds	Points
BD+C Without Furniture	2	1
	4	2
	5	3
BD+C With Furniture	3	1
	5	2
	6	3
Schools & Healthcare Without Furniture	3	1
	5	2
	6	3
School & Healthcare With Furniture	4	1
	6	2
	7	3

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Table 8: New Requirements and Standards for Category Thresholds

Product Type	Emission Type	Standard
Interior Wet Applied Paints & Coatings	Total VOCs	• California Air Resources Board (CARB) 2007, Suggested Control Measure for Architectural Coatings, or • South Coast Quality Management District (SCAQMD) Rules 1113, effective Jun 3, 2011 • California Department of Public Health (CDPH) Standard Method v1.1-2010, or • German AgBB Testing and Evaluation Scheme (2010), or • ISO 16000-3:2010, 16000-9:2006, 16000-11:2006 with AgBB or French legislation, or • DIBt testing method (2010)
Interior Wet Applied Adhesives & Sealants	Total VOCs	• SCAQMD Rule 1168, effective Jul 1, 2005, or • Canadian VOC Concentration Limits for Architectural Coatings* • California Department of Public Health (CDPH) Standard Method v1.1-2010, or • German AgBB Testing and Evaluation Scheme (2010), or • ISO 16000-3:2010, 16000-9:2006, 16000-11:2006 with AgBB or French legislation, or • DIBt testing method (2010)
Wet Applied Products	No added methylene chloride or perchloroethylene.	• None
Exterior Wet Applied Adhesives, Sealants, Paints & Coatings	Total VOCs	• Healthcare & Schools Only • CARB SCM for Architectural Coatings, 2007, and • SCAQMD Rule 1168, effective Jul 1, 2005, or • European Decopaint Directive (2004/42/EC or more recent version) Phase II, and • Local jurisdictional requirements.

EQ credit Low-Emitting Materials

Option 1
(1-3 points)
Product Category Calculations

OR

Option 2
(1-3 points)
Budget Calculation Method

Table 8: Continued

Product Type	Emission Type	Standard
Flooring	Total VOCs	• California Department of Public Health (CDPH) Standard Method v1.1-2010, or • German AgBB Testing and Evaluation Scheme (2010), or • ISO 16000-3:2010, 16000-9:2006, 16000-11:2006 with AgBB or French legislation, or • DIBt testing method (2010)
Inherently Non-Emitting	No integral organic-based surface coatings, binders or sealants, otherwise see Wet Applied Product Categories.	• None
Composite Wood	Formaldehyde	• CARB ATCM
Insulation for Ceilings, Walls, Thermal & Acoustic	Total VOCs	• California Department of Public Health (CDPH) Standard Method v1.1-2010, or • German AgBB Testing and Evaluation Scheme (2010), or • ISO 16000-3:2010, 16000-9:2006, 16000-11:2006 with AgBB or French legislation, or • DIBt testing method (2010)
Batt Insulation	Healthcare & Schools Only No added urea, phenol, or urea-extended phenol formaldehyde.	• None
Furniture	Total VOCs	• ANSI/BIFMA e3-2011 Furniture Sustainability Standard

*Note: Some standards contain higher VOC thresholds than others; when in doubt, use the standard with the lowest VOC thresholds for the applicable product.

This credit's two compliance options are summarized on the left side of this page.

Description

This credit requires that all products noted in the tables above, installed on the inside of the primary and secondary weatherproofing barriers, meet low VOC requirements. Note that some exterior wet applied products for Healthcare and Schools projects must also meet VOC standards. Wood products can contribute to this credit in a number of ways:

- Engineered wood products that contain glue, such as glulam, structural composite lumber products, and cross-laminated timber, which meet CARB's ultra-low emitting formaldehyde (ULEF) resin requirements or contain no added formaldehyde, will be compliant.
- Composite wood, and alternate-wood products, such as plywood, medium density fibreboard (MDF), oriented strand board (OSB), bamboo, wheatboard and strawboard, may comply with CARB requirements.

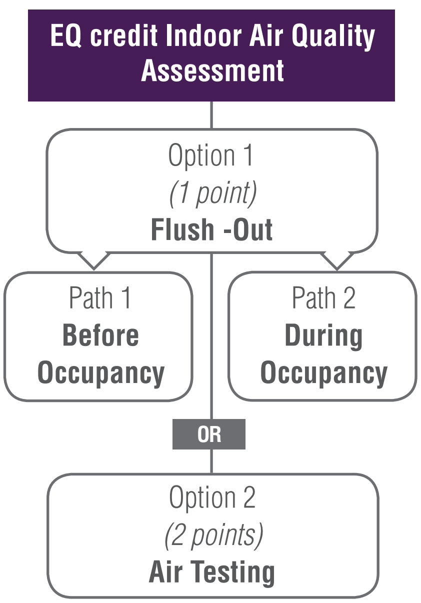
Tips for achieving this credit

- During schematic design, identify compliant flooring, composite wood, insulation and furniture products and collect compliant documentation.
- During design, make a decision regarding the VOC standards which will be used for the project (ACPs do exist for various locations); in general, choose the most stringent available standard.
- Provide detailed guidance on sourcing and documentation in the architectural and/or interior design specifications and drawings.
- During the investigation process, populate the materials tracker with compliant materials and compile a database of compliant products for future projects.
- Consider a policy of not accepting substitutes for compliant products.
- Review contractor s' proposed substitutions during pre-tender or tender and approve based on product document submission.
- Ensure sub-contractors are briefed about EPDs and the project's substitution policy prior to product ordering.
- Require all sub-contractors to submit compliant documentation, especially for VOC-emitting materials, prior to product ordering and installation on-site.
- Track all compliant products on-site.

Changes from LEED 2009

- EQc4.1, EQc4.2, EQc4.3 and EQc4.4 Low Emitting Materials have been combined into one credit with a scaled point system for each path earned.
- Furniture, insulation, and ceiling emissions limits from the LEED 2009 Healthcare rating system have been incorporated into one streamlined credit for all BD+C project types.
- Emissions requirements for on-site, wet-applied, full-spread products measured via chamber tests in air are now included. VOC content limits for on-site, wet-applied products are still required.
- Compliance of interior finishes may be demonstrated in assemblies with multiple layers in combination, or in each system individually.

Indoor Environmental Quality: Indoor Air Quality Assessment



Possible points for BD+C: 1-3

Intent: To establish better quality indoor air in the building after construction and during occupancy.[74]

Requirements:

This credit rewards project teams that perform an outdoor air flush-out (Option 1), or air quality testing (Option 2), of the project prior to substantial occupancy. This credit's two compliance options are summarized on the left side of the page.

Option 1 offers two compliance paths:

- Path 1: Full flush-out of 14,000 ft^3 of outdoor air per ft^2 before occupancy.
- Path 2: Partial flush-out before occupancy, a minimum of 3,500 ft^3 of outdoor air per ft^2; with the remaining 10,500 ft^3 of outside air per ft^2 flushed during occupancy, at a minimum rate of 0.30 ft^3 per minute per ft^2 of outdoor air.

Option 2 offers one compliance path:

Air quality testing for the following contaminants, which must not exceed LEED's pre-determined thresholds for each; all testing must comply with listed standards:

- Formaldehyde
- Particulates: PM10 and PM 2.5
- Ozone for buildings located in a US EPA non-attainment zone
- Total VOCs
- All targeted chemicals listed in CDPH Standard Method v1.1, Table 4-1
- Carbon monoxide

74 LEED v4 BD+C Reference Guide page 685

Description

This credit aims to ensure that adequate flushing of all construction-related emissions is completed before final occupancy to ensure a superior indoor air quality environment for occupants. Although both options have been available under previous versions of LEED, LEED v4 has dramatically increased the number and type of indoor air contaminants to be tested under Option 2. The CDPH standard lists thirty-five chemicals, such as benzene, monoethyl acetate, methyl t-butyl ether, phenol, toluene and xylenes, which have traditionally been staples on construction sites, thus increasing awareness around the harmful effects of these chemicals.

Wood products that do not contain added formaldehyde, and which do not require the use of CDPH chemicals during installation, can positively contribute to better indoor air quality within buildings during construction and occupancy.

PLC products that do not contain CDPH chemicals in their construction, and which do not require the use of CDPH chemicals during installation, can also positively contribute to better air quality for workers and occupants alike.

Tips for achieving this credit

- During early design, when project schedule is being compiled, allow sufficient time for both flush out and testing options, to ensure flexible options during construction.
- During the design phase, obtain flush-out duration from mechanical engineer, using the assumed installed system, set at 100%

outside air, and meeting the required temperature and relative humidity values; adjust project schedule to address this time constraint.

- During the design phase, conduct a space use analysis to determine the maximum number of required testing points in regularly occupied spaces served by separate ventilation systems. Ensure that the required 1 in 7 space testing requirement is followed for regularly occupied spaces which are the same type; examples include private offices and meeting rooms.
- During the design phase, confirm if the project is located in a non-attainment zone for ozone. If yes, ozone testing will be required. If no, obtain confirmation in writing from the mechanical engineer.
- If portable air handling systems are required for flush-out, ensure that language is carried on drawings and specifications to ensure proper sub-contractor costing of this item.
- During design, send out a request for proposals (RFP) to testing sub-contractors for early quotes, based on the space use analysis. Ensure that RFP language includes the list of 35 chemicals of concern identified by the California Department of Public Health, Standard Method of Testing version 1.1, Table 4-1, all other contaminants, and specifically note if ozone testing is required.
- Based on the quotes from the sub-contractors, decide if flush-out or testing will be chosen for credit compliance, before tendering all remaining construction contracts.
- Train relevant sub-contractors on required actions before flush-out and testing, setting a mandatory deadline which prohibits activities producing airborne pollutants a minimum of 24 hours before testing, and ensuring that all sub-contractors are aware of prohibited activities during flush-out and testing.
- If flush-out is chosen as the preferred methodology, ensure that site inspections are conducted during flush-out by the mechanical engineer, to ensure temperature and relative humidity levels are within compliance, and sufficient outdoor airflow volumes are being delivered.
- If testing is chosen, allow at least two weeks of grace period to allow for air quality lab results, and re-testing, as this may be necessary in:
  - Small rooms,
  - Rooms where a high number of VOC-containing products were applied or installed,
  - Rooms with higher concentration of composite wood, furniture and furnishing products,
  - Rooms where insufficient flush-out time was allowed prior to testing; any time period less than 24 hours prior to activities which result in airborne pollutants are at risk of failure.

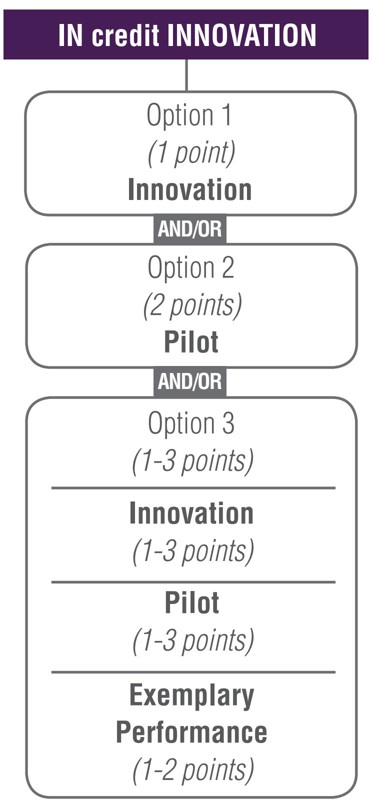
Changes from LEED 2009

- Movable furnishings installed before testing or flush-out is now required.
- Upper interior temperature limit is now identified in Option 1.
- Testing now includes all CDPH chemicals, (except for formaldehyde) under Option 2
- For project sites located in non-attainment zones, as defined by the US EPA, ozone testing is required.

Innovation

The Innovation category in LEED provides an opportunity for projects to receive LEED points for incorporating innovative strategies into projects. Innovation points can be awarded by achieving a credit from another rating system (e.g. LEED for Neighbourhood Development) that is not addressed in the project's chosen rating system, by choosing an innovative strategy not addressed in any rating system, by incorporating a LEED pilot credit into the project, and by achieving exemplary performance of a LEED credit. One additional innovation point can be awarded to a project that has a main team member who is a LEED Accredited Professional with the chosen rating system specialty.

Innovation: Innovation



Possible points for BD+C: 1-5

Intent:

To encourage projects to achieve exceptional or innovative performance.[75]

Requirements:

This credit rewards project teams that exceed performance thresholds for a given credit within the LEED rating system (exceptional performance), teams which propose a robust, measurable strategy which does not already exist within any of the LEED rating systems (innovative performance), or a team which attempts a pre-approved LEED pilot credit (pilot performance). Maximum thresholds exist for each of the above listed options (see Table 9).

A summary of compliance paths is noted in Table 10.

Table 9: Maximum Thresholds

Strategy Type	Maximum Points Threshold
Exemplary	2
Innovative	3
Pilot	3

75 LEED v4 BD+C Reference Guide page 779

Description:

Although this category provides a platform for creativity and the opportunity to focus project successes on non-LEED defined credits, the LEED rating system still provides significant guidance on achieving points under this category.

The LEED Reference Guide identifies all credits which qualify for Exemplary Performance, and describes the related threshold. Of the credits previously described in this guide, the following pre-qualify for Exemplary Performance:

In terms of using Innovative or Pilot credit strategies, there are several options:

- Innovative:
  - Use a credit from another LEED rating system, which is not included in BD+C.
  - Use a credit from another building rating system, such as the WELL Building Standard[76].
  - Design your own unique strategy.
- Pilot:
  - Register for a USGBC listed Pilot credit[77].

76 International WELL Building Institute (2017). URL: www.wellcertified.com
77 USGBC Pilot Credits (2017). URL: http://www.usgbc.org/pilotcredits

Table 10: Summary of Compliance Paths

Credit Name	Exemplary Performance Threshold	Wood & PLC Contribution
MR: Building Life Cycle Impact Reduction	Option 4: Realize reductions in all six impact categories.	Yes, contribution is possible.
MR: Building Product Disclosure & Optimization: EPDs	Option 1: Source forty products with EPDs, from at least five manufacturers. Option 2: Purchase products which contribute 70%, by cost, of the total cost of all permanently installed products.	Yes, contribution is possible.
MR: Building Product Disclosure & Optimization: Sourcing of Raw Materials	Option 1: Source forty products with EPDs from at least five manufacturers with publicly released reports which meet CSR frameworks. Option 2: Purchase products which contribute 50%, by cost, of the total cost of all permanently installed products.	Yes, contribution is possible.
MR: Building Product Disclosure & Optimization: Material Ingredients	Option 1: Source forty products with EPDs from at least five manufacturers with publicly released chemical inventories. Option 2: Purchase products which contribute 50%, by cost, of the total cost of all permanently installed products.	Yes, contribution is possible.
MR: Furniture and Medical Furnishings	Options 1, 2 or 3: Source furniture and furnishings which contribute 50%, by cost, to credit criteria.	Yes, contribution is possible.

Using wood can help achieve an Innovative strategy by looking at wood as a biophilic material. Biophilic design looks at incorporating nature and natural processes into the built environment. Exposed wood, as a natural material, is considered an indirect experience of nature, and has been shown to help reduce stress levels and improve performance of building occupants. Using wood can help achieve an innovation credit through biophilic design, either through a credit of the WELL Building Standard, Feature 88 Biophilia, Qualitative or Feature 100, Biophilia, Quantitative, or the Living Building Challenge Imperative 09, Biophilic Environments. Wood is just one of many strategies needed to achieve a biophilic design credit; however, it will significantly contribute to the success of the strategy.

Tips for achieving this credit

IN: Innovation

Tips for Achieving This Credit:

- As this category offers multiple compliance options, tips for each compliance type have been provided.

Image: Surrey Memorial Critical Care Tower incorporate many wood elements into the design[83] *(Image courtesy of EllisDon).*

Exemplary Performance (max 2 points):

- Identify viable exemplary performance thresholds during design and conduct feasibility and cost analysis before proceeding.
- Obtain team commitment for all targeted strategies.
- For design credits, collect documentation during design from project team.
- For construction credits, include guidance and criteria on specifications and drawings to ensure proper contractor pricing.[78]

Pilot Tips (max 3 points)

- Identify viable strategies during design and conduct feasibility and cost analysis before proceeding.
- Obtain team commitment for all targeted strategies.
- Register for the pilot credit through the USGBC website.
- Download USGBC pilot credit requirements upon registration; as pilot credits are often in flux, requirements may change or strategies could be deleted over time.
- Track challenges or difficulties with criteria during design and construction, and provide feedback to the USGBC upon project completion.
- For design credits, collect documentation during design from project team.
- For construction credits, include guidance and criteria on specifications and drawings to ensure proper contractor pricing.

Innovation Tips (max 3 points):

- Early on in design, at concept, discuss a biophilic design strategy for the project and review the appropriate biophilic design credits and strategies from WELL and the LBC. Have a full-day workshop reviewing the biophilic options for the project. Biophilic materials, including wood finishes, need to be included in design documents and in specifications.

78 http://inhabitat.com/beautiful-energy-efficient-surrey-hospital-expansion-targets-leed-gold-in-british-columbia/cei-surrey-memorial-10/

- Identify viable strategies during design and conduct feasibility and cost analysis before proceeding.
- Ensure strategies are sufficiently robust; review USGBC Pilot Credit Library and Interpretations to find out if other teams have already attempted this strategy.
- Consider submitting an informal request for technical guidance from the USGBC (free) or a formal Project Credit Interpretation (CIR - $220/credit) via LEED Online.
- If an original, independent strategy is not possible for the team, consider a credit from another LEED rating system, which is not represented in the BD+C rating system. If this strategy is chosen, follow all requirements and documentation outlined under this credit.
- Obtain team commitment for all targeted strategies.
- For design credits, collect documentation during design from project team.
- For construction credits, include guidance and criteria on specifications and drawings to ensure proper contractor pricing.

Referenced standards in this credit:

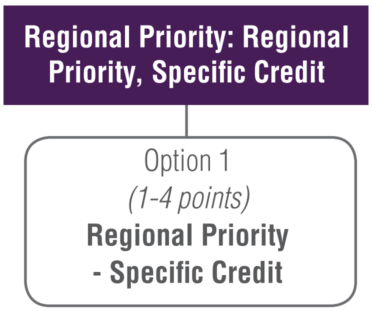
There are no referenced standards for this credit. However, if choosing to pursue biophilic design, consider reviewing the WELL Building Standard's Biophilia Features in the Mind Concept and the Living Building Challenge's Biophilic Environments Imperative in the Health and Happiness Petal.

An additional reference appropriate for this work and that informs both the LBC Imperative and WELL Features is:

Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life by Stephen Kellert, Judith Heerwagen, and Martin Mador.

Changes from LEED 2009

The maximum points threshold for exemplary performance has been reduced from three points in LEED 2009 to two points in LEED v4.



Regional Priority: Regional Priority, Specific Credit

Possible points for BD+C: 1-4

Intent: To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.[79]

Requirements:

Referring to the Regional Priority (RP) credit database on the CaGBC website[80], choose specific credits that are applicable to the project.

Description:

There are six RP credits that are designated to various geographic regions throughout Canada, in both rural and urban settings.

Tips for achieving this credit:

With regards to LEED credits that could apply for a RP credit using low carbon building materials, there is only one credit, which is the MRc Building Life-Cycle Impact Reduction is available for all locations throughout B.C.

Changes from LEED 2009

Applicable credits may have changed depending on geographic location.

79 LEED v4 BD+C Reference Guide page 791
80 LEED v4 Regional Priority Credit Selection: Canada (2017). URL: http://www.cagbc.org/cagbcdocs/leed/LEED_v4-Canada_Regional_Priority_Credit_Selection-EN-2017-01-18.pdf

Comprehensive Guide
LEED v4 and Low Carbon Building Materials

5.0 Conclusion

5.0 Conclusion

Projects that are pursuing LEED certification are well served by using low carbon building materials such as wood and PLC. LEED rewards the use of low carbon building materials, which is especially relevant as the system went through a thorough overhaul with the release of LEED v4. In order to continue the path towards a built environment that uses less carbon, choosing materials that contain less embodied carbon is crucial and have already been used for several years in B.C.

The building industry is moving towards a more holistic approach for low carbon building design, with a new emphasis on low carbon building materials as well as energy performance. By choosing wood, PLC and other low carbon building materials, designers and builders have the opportunity to create buildings that have less environmental harm than those that choose high carbon materials, while also having the opportunity to gain LEED points. Encouraging the use of low-carbon building materials in B.C. public sector infrastructure not only supports B.C.'s provincial climate objectives but can also contribute to Canada's national commitments and help to demonstrate B.C.'s leadership in climate action internationally.


Prince George Airport, B.C..

LEED v4 and Low Carbon Building Materials

6.0 Case Studies

6.0 Case Studies

Case Study: Ronald McDonald House BC & Yukon

BC Women's and Children's Hospital, Vancouver, B.C.

Overview

Completed in 2014, the Ronald McDonald House at the BC Women's and Children's Hospital in Vancouver provides a home-like environment for children and their families while undergoing treatment away from home. This LEED® Gold certified project expanded the original 12-family Shaughnessy House to a 73-family facility divided into four residential units connected by communal links. The facility was the first use of tilt-up cross-laminated timber (CLT) construction with pre-installed ledgers provided for interior timber I-joist floors, a construction solution that contributed toward an early completion date two months ahead of schedule. 9-ply CLT panels were used to carry the weight of green roofs and planters.

How low carbon materials were used in the project

Ronald McDonald House BC & Yukon made extensive use of wood, a building material that has a lower embodied carbon footprint than other building materials. A strategy used by the team was an innovative use of CLT tilt-up panels to speed erection. The panels were formed in the shop with cuts and notches where necessary for connections and openings, then larger wall sections were assembled horizontally on the ground and raised into place. This consideration for the erection process helped to save time on site and reduced the need for work at height, contributing to worksite safety. Floor and roof structures used pre-engineered timber I-joists and CLT panels supported on beams and ledgers on CLT walls.

RONALD MCDONALD HOUSE
Vancouver, B.C.

Level of LEED obtained:
LEED ® Canada NC 2009 Gold

Wood related LEED credits achieved:
MRc5 - Regional Materials

CLIENT
Ronald McDonald House BC and Yukon

ARCHITECT
Michael Green Architecture (MGA). Initiated by McFarlane Green Biggar Architecture + Design.

STRUCTURAL ENGINEER
Equilibrium Consulting Inc.

MECHANICAL ENGINEER
AME Consulting Group

LEED CONSULTANT
Kane Consulting Partnership

CONTRACTOR
ITC Construction Group; CLT by Structurlam Products

OCCUPANTS
65 families and staff members

NUMBER OF STOREYS
4

GROSS FLOOR AREA
6,875m²

Photo: Ema Peter

Photo: Ema Peter

Photo: Ema Peter

Photo: Ema Peter

Leadership in Energy and Environmental Design (LEED®)

The project was certified under LEED Canada NC 2009 and achieved points for using recycled content in building materials and local materials. LEED credits that were supported by low carbon building materials include Materials and Resources credit 5 - Regional Materials, for which the project exceeded 30%, gaining two LEED points.

Notable Awards

- 2016 Governor General's Award in Architecture
- 2015 Lieutenant-Governor of B.C. Award in Architecture (Merit)
- 2015 Masonry Institute of BC – Award of Excellence – Low Rise

References

Canada Green Building Council (CaGBC). www.cagbc.org

Michael Green Architecture Ltd. (2017). Ronald McDonald House BC. Accessed Feb. 2017. URL: http://mg-architecture.ca/work/ronald-mcdonald-house-bc/

Case Study: Wood Innovation & Design Centre

University of Northern British Columbia (UNBC), Prince George, B.C.

Photo: Ed White

Overview

When completed in 2014 the new Wood Innovation & Design Centre (WIDC) in downtown Prince George was, at 6 storeys, one of the tallest modern timber buildings in North America. Built in part to house a new Master of Engineering in Integrated Wood Design program at UNBC, the building features an open atrium and demonstration space, a lecture theatre, a workshop and laboratory, and spaces for faculty offices and classrooms. The upper three storeys of the building were left unfinished as rental space to be fit out to meet tenants' requirements.

How low carbon materials were used in the project

Building services were hidden by staggering the elevation of the cross-laminated timber (CLT) floor panels, creating voids for ducting, sprinklers, and lighting. Wood slats are also used to finish the walls and ceiling of the lecture theatre, creating visual appeal and contributing to the acoustics of the room.

The building makes extensive use of wood materials: CLT roof and floor panels are supported on a frame of glulam columns and beams; lateral bracing is provided by CLT shearwalls and a CLT structural core; and the sparse timber cladding is a mixture of charred and natural western red cedar on structural insulated panels and glazing with laminated veneer lumber (LVL) mullions. Interior finishes include stained wooden panels and slats, and an exposed wood stair with edge-laminated LVL treads rising from the demonstration space.

WOOD INNOVATION & DESIGN CENTRE
Prince George, B.C.

Level of LEED obtained:
LEED ® Canada CS 2009 Gold

Wood related LEED credits achieved:
MRc5 - Regional Materials
IEQc4.4 - Low-Emitting Materials: Composite Wood and Agrifiber Products
IDc1.1 - Exemplary Performance: MRc5
IDc1.2 - Life Cycle Analysis of a High Rise Wood Building

CLIENT
Province of British Columbia
Ministry of Jobs, Tourism and Skills Training and Responsible for Labour

ARCHITECT
Michael Green Architecture (MGA)

STRUCTURAL ENGINEER
Equilibrium Consulting Inc.

MECHANICAL ENGINEER
MMM Group Ltd.

LEED CONSULTANT
MMM Group Ltd.

CONTRACTOR
PCL Constructors Westcoast Inc.

NUMBER OF STOREYS
6

GROSS FLOOR AREA
4,820m²

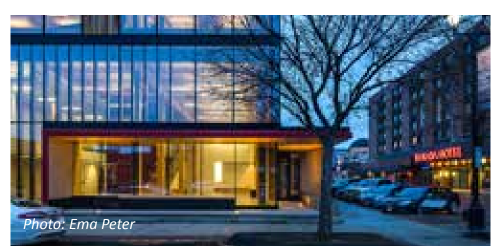


Photo: Ema Peter


Photo: Ema Peter


Photo: Ema Peter


Photo: Ed White

ENVIRONMENTAL IMPACT OF WOOD USE (Post-Construction Calculation)

VOLUME OF WOOD:
1519 cubic meters (53,623 cu ft.) of lumber and sheathing

U.S. AND CANADIAN FORESTS GROW THIS MUCH WOOD IN:
4 minutes

CARBON STORED IN THE WOOD:
1,099 metric tons of CO_2

AVOIDED GREEN HOUSE GAS EMISSIONS:
420 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
1,519 metric tons of CO_2

EQUIVALENT TO:

290 cars off the road each year

Energy to operate a home for 129 years

Based on: image by naturally:wood


Photo: Ed White

Leadership in Energy and Environmental Design (LEED®)

The Wood Innovation & Design Centre is certified LEED Gold under the LEED Canada 2009 Core and Shell rating system. The project achieved one Innovation in Design (ID) point for exemplary performance for using regional materials. To achieve this ID credit, at least 40% of the materials used on the project were extracted and manufactured within 800 km by road and 2,400 km by rail or water. An additional ID point was achieved by undertaking a life-cycle assessment of the building.

Awards

- 2016 Governor General's Award in Architecture
- 2015 RAIC Award of Excellence for Innovation in Architecture
- 2015 Lieutenant-Governor of B.C. Award in Architecture (Merit)
- 2015 AIBC Innovation Award

References

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Case Study: L´École Mer et Montagne

Conseil Scolaire Francophone de la Colombie-Britannique, Campbell River, B.C.

Photo: Derek Lepper

L'ÉCOLE MER ET MONTAGNE
Campbell River, B.C.

CLIENT
Conseil Scolaire Francophone de la Colombie-Britannique

ARCHITECT
McFarland Marceau Architects Ltd.

STRUCTURAL ENGINEER
Equilibrium Consulting Inc.

MECHANICAL ENGINEER
Bycar Engineering

CONTRACTOR
Newhaven Construction

NUMBER OF STOREYS
1 storey + mezzanine

GROSS FLOOR AREA
1,500m²

Overview

The new building at École Mer et Montagne in Campbell River opened in 2012 and replaced an existing elementary school building, while retaining and seismically upgrading an existing gymnasium. The École provides classrooms for 100 children ranging from Kindergarten to Grade 8.

Reclaimed Douglas Fir 3x12 joists were salvaged from the existing building and repurposed throughout the new school for large portions of the roof and corridors. Left exposed to view from below, the reclaimed timbers add warmth and contribute toward reducing the environmental impact of the building.

Timber features heavily in the finishes as well, in bookcases and a trio of rotating display cases in the middle of the school, reclaimed timber benches, and through timber acoustic ceiling panels along the corridors and a Media and Technology space.

How low carbon materials were used in the project

The building structure uses light-frame timber joists supported primarily on stud shearwalls. The existing gym structure was reinforced with post-tensioned steel rods and reinforced with additional nailing in the existing timber shearwalls and diaphragm, allowing for their re-use in the new building.

The project has received particular attention for the use of reclaimed Douglas Fir joists from the previous school building. The combination of new and reclaimed timber materials for both structure and finishes contributed toward sequestering or avoiding an estimated 198 tonnes of carbon dioxide equivalent.

Photo: Derek Lepper


Photo: Derek Lepper


Photo: Derek Lepper


Photo: Derek Lepper


Photo: Derek Lepper

Awards

- 2012 Woodworks BC Award – Small Institutional
- 2012 VIREB Commercial Building Awards - Merit
- 2012 Canadian Wood Council - Green Building Award
- 2011 Wood Design Award – Citation

References

McFarland Marceau Architects (2014). Vancouver, B.C.. Accessed Feb 2017. URL: http://www.mmal.ca/campbell/description.html

McFarland, L. (2013). Presentation at WoodWorks! Alberta Winter Wood Design Seminar, March 19-20, 2013. URL: http://www.wood-works.ca/wp-content/uploads/content/AB/Events/larry%20mcfarland_march%202013%20presentation.pdf

Case Study: Blueshore Environmental Learning Centre

North Vancouver School District 44, Brackendale, B.C.

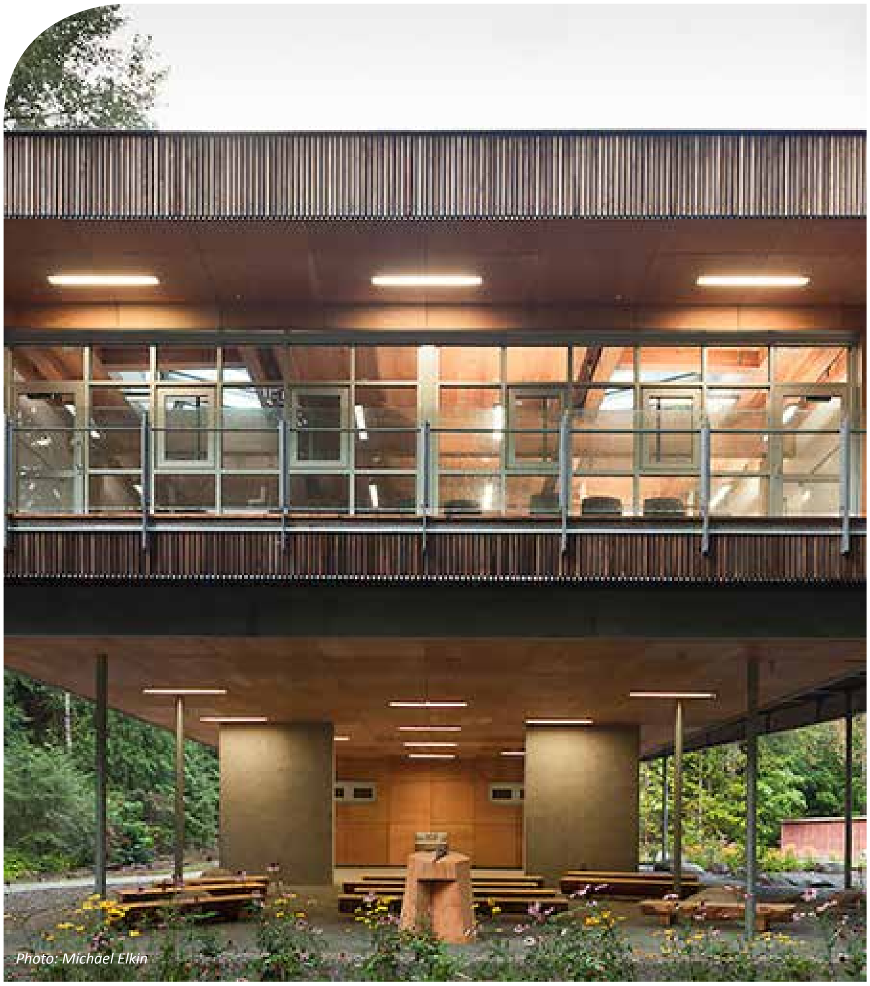
Photo: Michael Elkin

Overview

The BlueShore Environmental Learning Centre at the Cheakamus Centre in Brackendale is a striking timber structure raised up into the canopy of the surrounding forest. The classrooms are raised up on short concrete walls and steel columns to above the 200-year flood level of the nearby Cheakamus River. The covered ground level provides a sheltered gathering space from which classes can explore the surrounding area. The raised main building contains two classrooms and a large open multi-purpose room.

How low carbon materials were used in the project

Above the flood level, the structure is made up of a grid of glulam beams supporting cross-laminated timber panels at both floor and roof level. Wood is used in the cedar slat cladding that wraps the building, and for interior finishes, from the reclaimed Douglas Fir timbers that cover the soffit between glulam beams to the wooden millwork.

BLUESHORE ENVIRONMENTAL LEARNING CENTRE
Brackendale, B.C.

Level of LEED obtained:
LEED® Canada NC v1.0 Platinum

Wood related LEED credits achieved:
MRc5 - Regional Materials
MRc7 - Certified Wood
IEQc4.4 - Low-Emitting Materials: Composite Wood & Laminate Adhesives

CLIENT
School District 44, North Vancouver

ARCHITECT
McFarland Marceau Architects Ltd.

STRUCTURAL ENGINEER
Equilibrium Consulting Inc.

MECHANICAL ENGINEER
Stantec

LEED CONSULTANT
McFarland Marceau Architects Ltd.

CONTRACTOR
D.G.S Construction

NUMBER OF STOREYS
2

GROSS FLOOR AREA
950m²


Photo: Michael Elkin

Photo: Michael Elkin

Photo: Michael Elkin

Photo: Michael Elkin

Photo: Michael Elkin

Leadership in Energy and Environmental Design (LEED®)

The project was certified under LEED Canada NC 2009 and achieved points for using recycled content in building materials and using local materials. LEED credits that were supported by low carbon building materials include Materials and Resources credit 5 - Regional Materials, for which the project exceeded 30%, gaining two LEED points.

Notable Awards

- 2015 Canadian Wood Council Western Red Cedar Award
- 2013 Wood Design & Building Awards - Citation
- 2013 Lieutenant-Governor of British Columbia - Merit
- 2012 Holcim Award of Acknowledgment for Sustainable Construction
- 2012 Canadian Architect Awards of Excellence - Merit

References

McFarland Marceau Architects Ltd. (2014). BlueShore Financial Environmental Learning Centre at Cheakamus Centre. Accessed Feb 2017. URL: http://www.mmal.ca/northvan/page1.html

WoodWorks (2013). 2013 Wood Design Awards - Project Fact Sheet: Environmental Learning Centre, North Vancouver Outdoor School. Ottawa, ON: WoodWorks. URL: http://www.wood-works.ca/wp-content/uploads/content/BC/WDA/Winner2012/FactSheets/elc.pdf

Case Study: TELUS Garden Office

Vancouver, B.C.


Photo: Henriquez Partners Architects; Photographer Ed White

Overview

TELUS Garden Office is part of the TELUS Garden complex located at 510 West Georgia in Vancouver. Completed in 2015 this project was the first Canadian project to be awarded LEED Platinum under the LEED Canada 2009 Core and Shell rating system. The project is the headquarters of TELUS and boasts many sustainability features including sky gardens, the use of low emitting materials and on-site renewable energy through photovoltaic panels.

How low carbon materials were used in the project

TELUS Garden was one of the first projects to be built in Vancouver using Portland-limestone cement (PLC), a cement product that has 10% less embodied carbon than regular Portland cement. PLC is branded in Canada under the name Contempra® and is manufactured in the Metro Vancouver region. PLC is created by adding 6-15% limestone with cement clinker.

The use of wood was also incorporated into the building with a 67 metre steel-glulam span creating an arched canopy, which is an integral architectural feature of the project.

TELUS GARDEN OFFICE
Vancouver, B.C.

Level of LEED obtained:
LEED® Canada CS 2009 Platinum

Wood related LEED credits achieved:
MRc5 - Regional Materials
MRc6- Certified Wood
IEQc4.4 - Low-Emitting Materials: Composite Wood & Agrifiber Products

CLIENT
Westbank Projects Corp.

ARCHITECT
Henriquez Partners Architect

STRUCTURAL ENGINEER
Glotman Simpson

LEED CONSULTANT
Icon/Light House Sustainable Building Centre

CONTRACTOR
Icon Construction

OCCUPANTS
Over 1900 for retail and office

NUMBER OF STOREYS
22

GROSS FLOOR AREA
47,000m²

Photo: Henriquez Partners Architects. Photographer Ed White

Photo: Henriquez Partners Architects. Photographer Ed White

Leadership in Energy and Environmental Design (LEED®)

The project was certified to LEED Canada Core and Shell Platinum. Just under 60% of all wood based materials were from Forest Stewardship Council (FSC®) sources, resulting in the achievement of Materials and Resources credit 6 (MRc6) - Certified Wood.

The project also achieved full points MRc4 - Recycled Content (30%) and for MRc5 - Regional Materials (37%).

Awards

- 2016 Architizer A+ Award

References

Canada Green Building Council (CaGBC). www.cagbc.org

http://henriquezpartners.com/work/telus-garden/

http://www.glotmansimpson.com/project/telus-garden-vancouver/

http://westbankcorp.com/press/telus-garden-wins-architizers-top-awards#.WLicNW_yu01

http://www.vancitybuzz.com/2015/09/telus-garden-office-tower-vancouver/

Case Study: Brock Commons Tallwood House

University of British Columbia (UBC), Vancouver, B.C.

Photo: www.naturallywood.com

Overview

Brock Commons Tallwood House is a landmark 18-storey residence building at UBC in Vancouver with 17 storeys of wood and concrete construction over a single storey concrete podium. At 53 metres, it is the tallest contemporary wood hybrid building in the world to-date. Brock Commons provides the University with over 400 student beds, with a shared ground floor study and social space.

How low carbon materials were used in the project:

Flat cross-laminated timber (CLT) floor plates were used with a grid of glulam columns and two concrete building cores. Dropped beams were avoided through the innovative use of two-way spanning CLT supported only on columns at each corner. The result is an open floor area interrupted only by the grid of columns and the building cores, reducing the impact of the structure on the end use of the space.

Erection of the timber elements was completed in less than 70 days, due largely to savings from off-site prefabrication. Careful design of the column connections allowed for quick installation of the floors and columns, facilitating the assembly of two storeys of structure per week. As the structure was installed prefabricated exterior wall panels were lifted into position with windows and cladding in place, closing the envelope as the building went up.

A Site-Specific Regulation from the British Columbia Building Safety & Standards Branch was required for approval of the building, which exceeds the code-specified height restriction of 6 storeys. To simplify the approval process, building cores were constructed using concrete rather than mass timber, and the timber structure was covered with multiple layers of gypsum board to provide fire resistance exceeding that which would be required for a similar steel or concrete building.

BROCK COMMONS TALLWOOD HOUSE
Vancouver, B.C.

Level of LEED® targeted:
LEED v4 BD+C Gold

CLIENT
University of British Columbia

ARCHITECT
Acton Ostry

TALL WOOD ADVISOR
Architekten Hermann Kaufmann

STRUCTURAL ENGINEER
Fast + Epp

LEED CONSULTANT
Stantec

FIRE AND CODE CONSULTANT
GHL Consultants

CONTRACTOR
Urban One Builders, Seagate Structures and Structurlam Products Ltd.

NUMBER OF STOREYS
18

GROSS FLOOR AREA
15,115m²

Photo: www.naturallywood.com

Photo: www.naturallywood.com

Leadership in Energy and Environmental Design (LEED®)

This project is targeting LEED v4 BD+C: NC Gold certification. A highlight credit that the project is pursuing is the new to LEED v4 credit, MRc Building Life-Cycle Impact reduction, Option 4, Whole-Building Life-Cycle Assessment.

References

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