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DEMONSTRATING THE BENEFITS OF WHOLE-BUILDING LIFE CYCLE ASSESSMENT

REDUCING THE IMPACT OF THE BUILT ENVIRONMENT

The goal of green design is to achieve sustainability by designing and building structures that use less energy, water and materials, and minimize impacts on human health and the environment.

Life cycle assessment (LCA) supports this by quantifying the environmental impacts of resource consumption, emissions and waste throughout the building's life. Governments and building owners are increasingly moving towards LCA as a way of assessing climate change and other environmental impacts of buildings.

Pacific Autism Family Centre | Architect: NSDA Architects | Photo: Derek Lepper

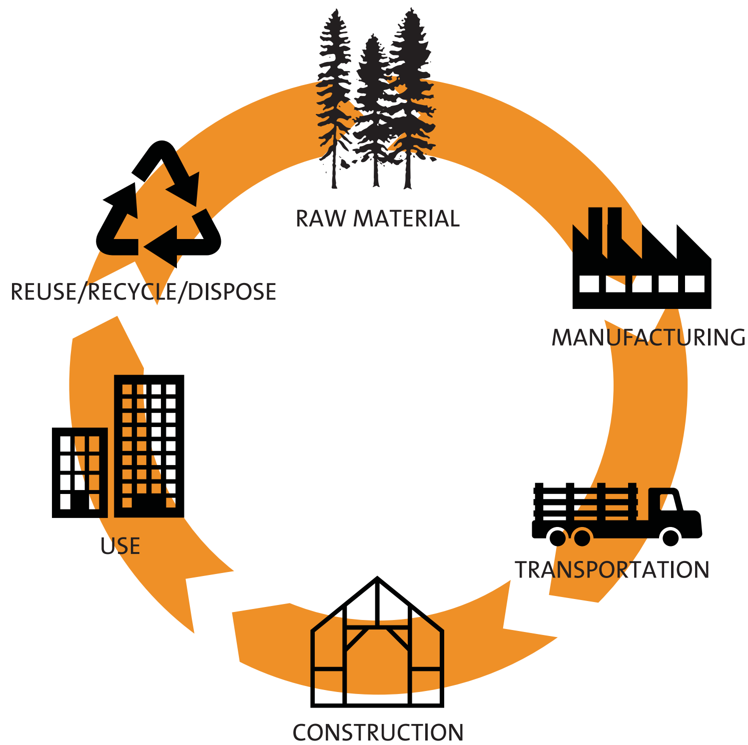
Using LCA to support the best environmental choice

The choice of products used to build, renovate and operate structures of all types has a huge impact on the environment, consuming more of the earth's resources than any other human activity, and producing millions of tonnes of greenhouse gases, toxic emissions, water pollutants and solid waste.

Building with the environment in mind can reduce this negative impact. But to be effective, decisions need to be based on a standardized, quantified measurement system that allows impartial comparison of materials and assemblies over their entire lives.

The most widely accepted scientific method to compare design choices and building materials effectively is life cycle assessment. LCA is a performance-based approach to assessing the impacts building material choices have on the environment at every stage of life — from the extraction of raw materials through manufacturing, transportation, installation/construction, use, maintenance, and reuse/disposal/recycling.

LCA has existed in various forms since the early 1960s, and the protocol for completing life cycle assessments was standardized by the International Organization for Standardization (ISO 14040/14044). It is incorporated into many green building rating systems and government policies, such as the City of Vancouver's Embodied Carbon Strategy and the Federal Pan-Canadian Framework on Clean Growth and Climate Change.



Nine studies show the power of LCA

The studies for the following wood and concrete projects in British Columbia illustrate some of the different uses of whole-building LCA.

Environmental building declaration communicates the environmental footprint of a building:

- Eight-storey office building — Wood Innovation and Design Centre
- Eighteen-storey student residence — Brock Commons Tallwood House
- Seventeen-storey student residence — Ponderosa Commons Cedar House

Sensitivity analysis is used to understand the environmental impact of changes in the building design and materials used:

- Industrial/manufacturing facility — StructureCraft
- Hotel — Lakeside Resort expansion
- School — Kwakiutl Wagalus Elementary School

Green building rating programs earn credits in systems such as Green Globes and LEED:

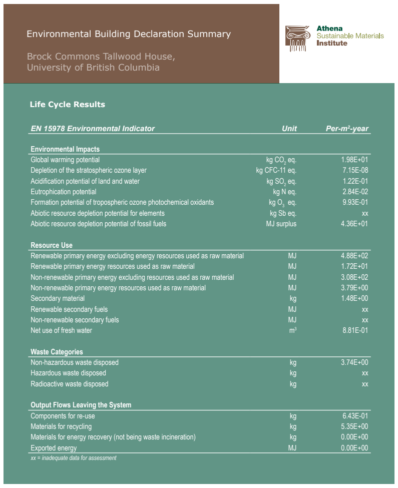
- Community/Administrative — Tsleil-Waututh Administration and Health Centre
- Health centre — Pacific Autism and Family Centre
- Six-storey mixed-use built to Passive House standard — The Heights

All of the LCAs in this factsheet include the following impact categories:

- Global warming potential
- Ozone depletion potential
- Acidification potential
- Eutrophication potential
- Smog formation potential
- Non-renewable primary energy use

Global warming potential (GWP) and non-renewable energy use are often viewed as critical to reduce. GWP reflects life-cycle carbon footprint, or **embodied carbon**.

LCA FOR ENVIRONMENTAL BUILDING DECLARATION



Environmental Building Declaration Summary

Brock Commons Tallwood House,
University of British Columbia

Athena Sustainable Materials Institute

Life Cycle Results

EN 15978 Environmental Indicator	*Unit*	*Per-m²-year*
Environmental Impacts		
Global warming potential	kg CO_2 eq.	1.98E+01
Depletion of the stratospheric ozone layer	kg CFC-11 eq.	7.15E-08
Acidification potential of land and water	kg SO_2 eq.	1.22E-01
Eutrophication potential	kg N eq.	2.84E-02
Formation potential of tropospheric ozone photochemical oxidants	kg O_3 eq.	9.93E-01
Abiotic resource depletion potential for elements	kg Sb eq.	xx
Abiotic resource depletion potential of fossil fuels	MJ surplus	4.36E+01
Resource Use		
Renewable primary energy excluding energy resources used as raw material	MJ	4.88E+02
Renewable primary energy resources used as raw material	MJ	1.72E+01
Non-renewable primary energy excluding resources used as raw material	MJ	3.08E+02
Non-renewable primary energy resources used as raw material	MJ	3.79E+00
Secondary material	kg	1.48E+00
Renewable secondary fuels	MJ	xx
Non-renewable secondary fuels	MJ	xx
Net use of fresh water	m^3	8.81E-01
Waste Categories		
Non-hazardous waste disposed	kg	3.74E+00
Hazardous waste disposed	kg	xx
Radioactive waste disposed	kg	xx
Output Flows Leaving the System		
Components for re-use	kg	6.43E-01
Materials for recycling	kg	5.35E+00
Materials for energy recovery (not being waste incineration)	kg	0.00E+00
Exported energy	MJ	0.00E+00

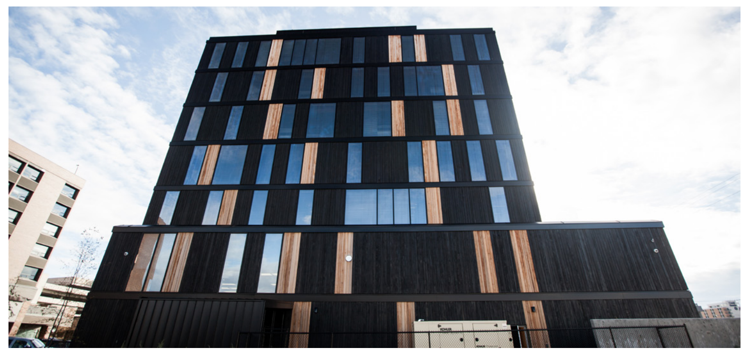
xx = inadequate data for assessment

All new buildings have a large embodied footprint — understanding these burdens is the first step to reducing them. An environmental building declaration (EBD) can help a design practice or building owner establish a personal benchmark for future projects. Publishing an EBD adds a performance accountability component to sustainable design that goes beyond prescriptive checklists of green building rating programs. EBDs are typically publicly disclosed and can be put on a sign on the building like a nutrition label on a food package. The EBDs for the following three buildings are compliant with EN 15978. While European in scope, EN 15978 is the most advanced consensus standard for whole-building LCA and quickly becoming the worldwide standard. The *National Guidelines for Whole-building Life Cycle Assessment* by the National Research Council of Canada comply with EN 15978 and relevant ISO standards (found at nrc-publications.canada.ca).

These EBDs are available at athenasmi.org.

Wood Innovation and Design Centre

Completed in October 2014, the Wood Innovation and Design Centre is six storeys and 4,820 square metres. The Prince George office building utilized dimensional lumber, plywood panels and western red cedar siding as well as glue-laminated timber (glulam), cross-laminated timber (CLT), parallel strand lumber (PSL), and laminated veneer lumber (LVL), all of which were produced in British Columbia. The simplicity of the building — a clean, modern box — lends itself to being a repeatable and expandable template for future tall wood office buildings.



Wood Innovation and Design Centre | Architect: MGA | Michael Green Architecture | Photo: Brudder

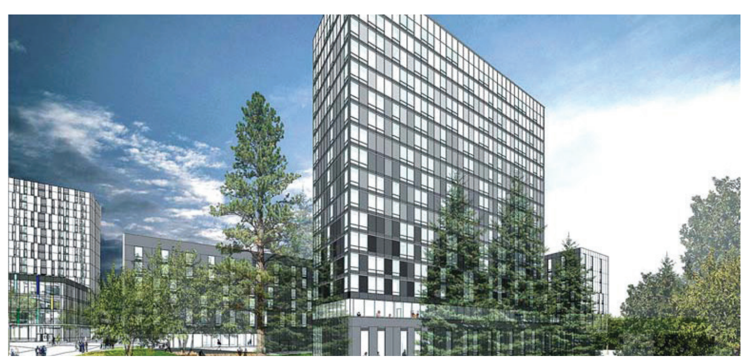
Brock Commons Tallwood House and Ponderosa Commons Cedar House

Brock Commons Tallwood House, a mass timber hybrid structure, and Ponderosa Commons Cedar House, a reinforced concrete building are two student residences at the University of British Columbia. Both completed in 2017, Ponderosa Commons, sits at 17 storeys and 12,838 square metres and Brock Commons is an 18 storey, 15,115 square metre structure which features CLT, PSL and glulam.

A comparison analysis and a sensitivity analysis were conducted on the two building EBDs. The comparison analysis showed that in terms of life cycle stage and activities, the production stage was the greatest contributor of the environmental impacts. When the structural elements were compared, Tallwood House performed better in all impact categories. Tallwood House also performed better when considering recovery beyond the life of the building and carbon sequestration.

The sensitivity analysis showed that utilizing more mass timber, resulted in reduction of negative impacts in most categories and increase in positive impacts in most categories.

Brock Commons Tallwood House | Architect: Acton Ostry Architects Inc. | Photo: Brudder



Ponderosa Commons Cedar House | Rendering courtesy of KPMB Architects, HCMA & UBC

LCA FOR SENSITIVITY ANALYSIS

Sensitivity analysis considers the material used in the building and how the change in the quantity of materials used affects cradle-to-grave impacts.

This analysis is required by the whole-building LCA standard EN 15978 to determine the significance of the influence of the data chosen for the assessment.

Canada's *National Guidelines for Whole-building Life Cycle Assessment* provides guidance on carrying out a sensitivity analysis.

StructureCraft Manufacturing Facility

StructureCraft's manufacturing facility in Abbotsford, was erected in just five days in 2017. Designed and built as a demountable structure, with modular wood wall and roof panels, the building includes 4,000 square metres of manufacturing and about 645 square metres of office space. Glulam beams and columns form the structural frame of the new facility, and architectural quality nail-laminated timber (NLT) panels were used for the roof of the office portion of the building.

The sensitivity analysis determined that for every 10% change in the quantity of materials used in the StructureCraft manufacturing facility, the impact results were most sensitive to changes in the use of concrete & steel reinforcement (4%) and structural wood products (1%) and TPO roofing membrane (1%). This indicates that changes to the use of concrete and reinforcement would be most effective to reduce the cradle-to-grave impacts of the building.

StructureCraft Manufacturing Facility | Architect: Keystone Architecture | Photo: courtesy of StructureCraft Builders

Lakeside Resort Expansion

The Lakeside Resort expansion in Penticton, is a 70-unit, 5,150 square metre hotel constructed of mass timber. Speed of construction, reduced building weight and desire for a more attractive facility convinced the Lakeside Resort owner to use wood instead of concrete when they expanded their resort in 2016. The structure was framed by Douglas-fir glulam beams and columns, left exposed to the interior. Glulam was also used to build a dramatic 30-foot high wall using a double lattice of beams to frame the windows. CLT panels were used for all major shear elements of the building and to frame the stairwells and stairs.

Penticton Lakeside Resort | Architect: HDR | CEI | Photo: Jon Adrian

The sensitivity analysis determined that for every 10% change in the quantity of materials used in the Lakeside Resort expansion, the impact results were most sensitive to changes in the use of concrete & steel reinforcement (4%), structural wood products (2%) and SBS roofing membrane (0.4%). This indicates that changes to the use of concrete and reinforcement would be most effective to reduce the cradle-to-grave impacts of the building.

Kwakiutl Wagalus School

The use of wood in buildings, and as part of daily life, is an integral part of the heritage and culture of the Kwakiutl First Nation. The 1,648 square metre Port Hardy school, completed in 2016, features western red cedar from local forests in every aspect of the building's design. Special effort was made to highlight the use of wood as a prominent structural element as well as for interior and exterior finishes. Douglas-fir and spruce-pine-fir are also featured in the building. The school's gymnasium was designed as a system of prefabricated tilt-up wood panels to speed up construction. It took just 19 days to erect the gym walls and nine days to add the roof, allowing the gym to be enclosed quickly and avoid exposure to rain during construction.

Kwakiutl Wagalus School | Photo courtesy of Lubor Trubka Associates Architects | Photo: Peter Powles Photography

The sensitivity analysis determined that for every 10% change in the quantity of materials used in the Kwakiutl Wagalus School, the impact results were most sensitive to changes in the use of concrete & steel reinforcement (3%), structural wood products (0.4%) and roof envelope (0.3%). This indicates that changes to the use of concrete and reinforcement would be most effective to reduce the cradle-to-grave impacts of the building.

LCA FOR LEED V4 CREDIT

Leadership in Energy and Environmental Design (LEED) promotes sustainability focused practices in the building industry. LEED v4 Building Life-cycle Impact Reduction credit, awards points for reductions in environmental impact to encourage designers to explore early design alternatives.

The LEED credit uses six impact categories, to compare the environmental performance of two functionally equivalent designs. The **proposed** design must demonstrate a lower environmental impact relative to a hypothetical early stage design of the building, referred to as the **baseline** design, so it can earn the LEED whole-building LCA credit points.

Tsleil-Waututh Administration and Health Centre

The 2,341-square-metre Tsleil-Waututh Administration and Health Centre, is a hub for the Nation's administration, governance, health and social services. It is expressive of Tsleil-Waututh's philosophy and cultural heritage, and the undulating roof celebrates in architectural form the symbiotic relationship between the Tsleil-Waututh people and the sea. Wood is featured prominently in the structure and finishes, emphasizing the relationship to the natural world — and allowing the use of both traditional and innovative building techniques.

Comparing environmental impacts

The Tsleil-Waututh Administration and Health Centre, exceeded the baseline design in five of the six impact categories and the building would earn three LEED points. This was achieved by using wood studs and I-joists and NLT rather than the steel studs and joists and concrete suspended slabs proposed in the baseline design.

By using wood studs, I-joists and NLT, the Tsleil-Waututh Administration and Health Centre reduced its global warming impact related to material use in the structure (embodied carbon) by 16% or 200 tonnes CO_2 equivalent.

Tsleil-Waututh Administration & Health Centre | Architect: Lubor Trubka Associates | Photo: Dr. Roman Trubka

The Heights

The Heights is a six-storey, mixed-use building that opened in 2017 in the Vancouver Heights neighbourhood. The basement parking garage and street level retail space are built with concrete, and this is topped by five storeys of wood-frame residential accommodation.

The 5,725-square-metre structure has 85 apartments and is one of the largest Passive House certified buildings in Canada. Wood-frame construction was both the most economical choice for this structure and contributes to the overall performance of the building envelope.

The Heights | Photo: Cornerstone Architecture

Comparing environmental impacts

The Heights saw improvements in all six impact categories when compared to the baseline design and would earn four LEED points. This was achieved by using engineered and solid wood floor and roof systems instead of reinforced concrete.

By using engineered and solid wood floor and roof systems, The Heights reduced its global warming impact related to material use in the structure (embodied carbon) by 31% or 800 tonnes CO_2 equivalent.

Pacific Autism Family Centre

The Pacific Autism Family Centre, which opened in 2016, brings together resource, education and recreation facilities to address the growing challenge of autistic spectrum disorder, the most common neurological disorder in children in British Columbia.

The three-storey, 5,751-square-metre structure in Richmond was designed to present a calming environment, including oversized waiting areas to prevent feelings of claustrophobia or confinement. Wood reinforced the welcoming atmosphere, and offered a cost-effective structural solution with long spans that could accommodate future reconfiguration should the needs of autism research and treatment change.

Pacific Autism Family Centre | Architect: NSDA Architects | Photo: Derek Lepper

Comparing environmental impacts

The Pacific Autism Family Centre, saw improvement in all six impact categories when compared to the baseline design and would earn four LEED points. This was achieved primarily by using engineered and solid wood floor and roof systems supported on engineered wood beams and columns. The baseline design recommended composite metal floor and roof systems supported on wide flange steel beams and columns.

By using engineered and solid wood floor and roof systems, the Pacific Autism Family Centre reduced its global warming impact related to material use in the structure (embodied carbon) by 27% or 600 tonnes CO_2 equivalent.

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Student study space on 18th-storey of Brock Commons Tallwood House | Architect: Acton Ostry Architects Inc. | Photo: Michael Elkan Photography

Getting started with LCA

User-friendly LCA tools provide life cycle impact information for building materials and for whole buildings. Data is also available for many materials in the form of easy-to understand, standard format **environmental product declarations (EPD)**.

Simplified whole-building LCA tools provide cradle-to-grave LCA results for many generic building assemblies without requiring users to have LCA expertise.

Athena Impact Estimator for Buildings, One Click LCA and **Tally** are the most widely used whole-building LCA tools in North America.

Providing measurable details about a building's environmental impacts offers wide benefits. Its primary benefit is to equip the design team with the information needed to reduce environmental impacts over a business-as-usual design. It gives design teams a competitive advantage by positioning them as industry leaders. Clients can use the information to inform their marketing and climate change mitigation strategies.

As green building rating programs in North America shift from prescriptive to performance provisions, they turn to LCA and other analytical tools to award credits.

FOR MORE INFORMATION
LCA TOOLS AND CARBON CALCULATORS

IMPACT ESTIMATOR FOR BUILDINGS
Athena Sustainable Materials Institute
athenasmi.org/our-software-data/impact-estimator

TALLY
Building Transparency, KT Innovations choosetally.com

EMBODIED CARBON IN CONSTRUCTION CALCULATOR (EC3)
Building Transparency buildingtransparency.org

ONE CLICK LCA
Bionova oneclicklca.com

EMBODIED CARBON PATHFINDER
City of Vancouver buildingpathfinder.com

CARBON CALCULATOR
Canadian Wood Council cwc.ca/en/design-tools/carbon-calculator

CARBON CALCULATOR FOR HARVESTED WOOD PRODUCTS
BC Ministry of Forests
www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nrs-climate-change/mitigation/users_manual_july_19_2016.pdf

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