Wood Specification: Life Cycle Assessment

The best way to determine the full environmental impacts of a building product or design is through life cycle assessment (LCA). LCA analyzes the total environmental impacts of all materials and energy flows, either as input or output, over the life of a product from raw material to end-of-life disposal or to rebirth as a new product. For buildings and building products this includes resource extraction, manufacturing, on-site construction, occupancy, and eventual demolition and disposal or reuse. LCA-based Environmental Product Declarations (EPDs) also provide information about environmental impacts during the manufacture and life of a product. All of the major green building rating systems and model codes in North America recognize and encourage use of LCA and/or EPDs in building design and materials selection.

Terminology

Typical environmental impacts of interest:

Material usage: amount of material used, expressed in terms of mass and/or volume.

Embodied energy: amount of energy associated with extracting, processing, manufacturing, transporting, and assembly of building materials.

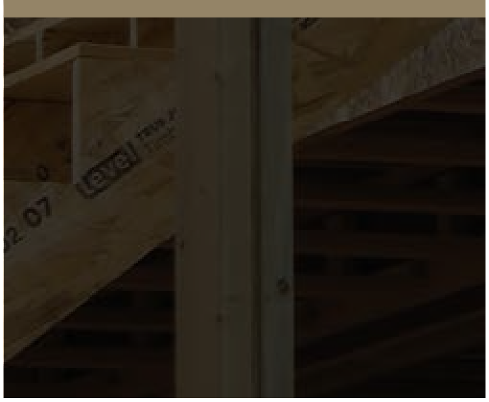
Global Warming Potential (GWP): a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to the same mass of carbon dioxide (the GWP of which is by convention equal to 1). A GWP is calculated over a specific time interval which must be stated whenever a GWP is quoted.

Air pollution: sulphur dioxide, nitrous oxides, methane, particulates, and volatile organic compounds.

Solid waste generation: solid waste generated during manufacturing and construction.

Water consumption: quantity of water use associated with a material process.

Water pollution: the effluent deposited into water bodies.



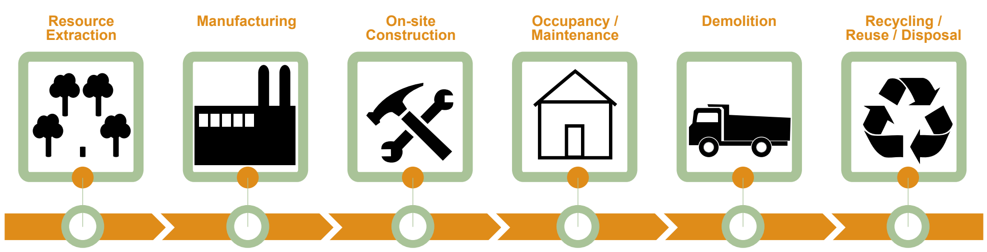
Why Life Cycle Assessment Adds Value

- Sustainable design is complex and integrated. One way to understand the complex interaction of factors involved in new construction, renovation, and retrofits is through life cycle assessment. LCA provides information about ongoing environmental impacts of building operation as well as upstream environmental burdens of the building materials and products.
- LCA provides measurable outputs that can help clients make meaningful decisions that not only affect their real estate portfolio but also inform their climate change mitigation strategies and their corporate marketing and recruitment efforts.
- Commercial building clients are looking more closely at the environmental impacts of their operations and investments. Spurred by regulation and market forces, many corporations are committing to reporting their quality assurance and environmental initiatives and to tracking their improvements.
- Application of LCA to building design and use of LCA and/or EPDs in materials selection can gain credits in pursuit of green building certification.
- The LCA process is defined under International Organization for Standardization (ISO) 14044 (Environmental Management—Life Cycle Assessment—Principles and Framework / Environmental Management—Life Cycle Assessment—Requirements and Guidelines) which is part of the internationally recognized series of standards that address environmental management and is familiar to most businesses.

An **Environmental Product Declaration** (EPD) is a standardized report of environmental impacts linked to a product or service. More explicitly, an EPD is a standardized, third-party verified, and LCA-based label that communicates the environmental performance of a product and that is applicable worldwide.

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

Incorporating LCA positions a business as an industry leader and provides it with a competitive advantage, particularly in markets where LCA is recognized. Taking a proactive position also reduces costs associated with future regulatory compliance.



Life Cycle of Building Products

How to Include Life Cycle Assessment in Design

Early green building rating initiatives in North America were built upon lists of specific prescribed measures for reducing energy consumption and various environmental impacts. Such measures remain in place today within many green building rating systems. Arranged within categories such as Energy, Water, Indoor Air Quality, Materials and Resources, and Site, prescriptive lists of recommended or required measures for addressing specific concerns outline the path toward environmentally better buildings. Each measure typically addresses a single concern or attribute such as recycled, recycled content, rapidly renewable, and local. Recommendations for improving environmental performance of buildings and construction practices have long varied among the various rating initiatives. Within this context, recommendations for use of wood and wood products varied as well.

Centre for Interactive Research on Sustainability (CIRS), UBC
Architect: Perkins+Will Canada Architects Co.
Photo: Don Erhardt

Most of the 42 green building programs in use in North America today continue to rely on prescriptive provisions. However, a shift away from prescriptive measures and toward performance and systematic assessment has begun that is reflected in Green Globes, LEED and several other rating systems, as well as in CalGreen, and in the IgCC and ASHRAE 189.1 model codes.

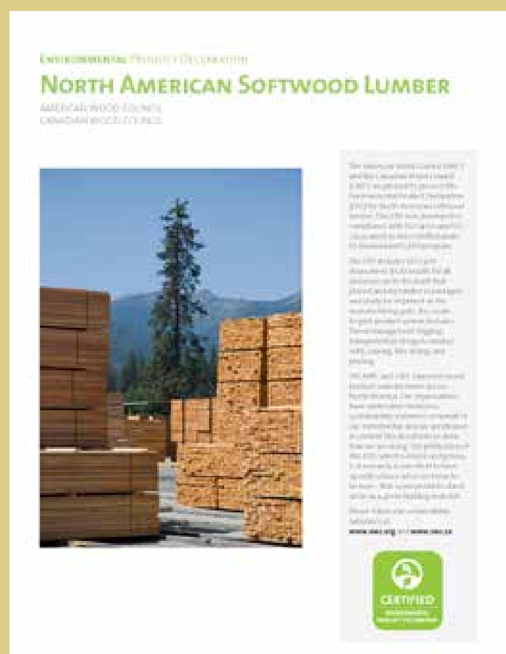
The move away from a prescriptive basis and toward a performance basis involves emphasis on reliance on systematic, life cycle assessment-based tools and sources of information. It is a major step forward, and a change that allows simultaneous, systematic, science-based consideration of multiple attributes rather than adherence to intuition-based single attributes.

Credit can be achieved (and invaluable information about building design can be gained) through use of life cycle assessment of at least two alternative designs or of successive iterations in the design process. Use of EPDs to inform building product choices also provides essential information while also gaining credits within leading green building programs.

Applicable worldwide, EPDs are a standardized (ISO 14025) tool for communicating the environmental performance of a product or system. Europe, Asia and Australia have been the most advanced economies to use environmental product declarations.

Next Steps: Where Proficiency in Life Cycle Assessment can Lead

Life cycle assessment (LCA) is sometimes described as mysterious and extremely complicated. Yet, what is involved is simply a thorough accounting of resource consumption, including energy, and emissions and wastes associated with production and use of a product. For a "product" as complex as a building this means tracking and adding up inputs and outputs for all assemblies and subassemblies – every framing member, panel, fastener, finish material, coating, and so on. Further, to ensure that results and data developed by different LCA practitioners and in different countries are comparable (i.e. that results allow apples to apples comparisons) LCA practitioners must strictly adhere to a set of international guidelines as set forth by the International Organization for Standardization (ISO). Tracking products and co-products through a supply chain and properly allocating resource use, emissions and wastes to various outputs can indeed be a complicated and expensive procedure for those who conduct assessments. However, for users of LCA tools, information has never been easier to access. User-friendly, low-cost (in most cases free) LCA tools allow building designers to rapidly obtain life cycle impact information for an extensive range of generic building assemblies, or with a bit more work and modest investment to develop full building life cycle analyses on their own. LCA-based data is now also available in the form of easy-to-understand, standard format environmental product declarations (EPDs) for a wide range of products.


NORTH AMERICAN SOFTWOOD LUMBER

Rule of Thumb

Material	Embodied energy, ranked by density MJ/m^3
Straw bale	31
Cellulose insulation	112
Mineral wool insulation	139
Aggregate	150
Soil-cement	819
Fiberglass insulation	970
Lumber	1,380
Stone, local	2,030
Concrete, block	2,350
Concrete, precast	2,780
Concrete (30 MPa)	3,180
Polystyrene insulation	3,770
Particleboard	4,400
Shingles, asphalt	4,930
Brick	5170
Plywood	5,720
Gypsum insulation	5,890
Aluminium, recycled	21,870
Steel, recycled	37,210
Glass	37,550
Carpet, synthetic	84,900
PVC	93,620
Paint	117,500
Linoleum	150,930
Steel	251,200
Zinc	371,280
Aluminium	515,700
Brass	519,560
Copper	631,164

Source: The Canadian Architect www.canadianarchitect.com/asf/perspectives_sustainibility/measures_of_sustainablity/measures_of_sustainablity_embodied.htm

Note: this table does not differentiate the impacts and efficiencies of source energy generation used in extraction, transportation or manufacture. For example, the Swiss Minergie rating system (www.minergie.com) weights energy carrier and sources as follows: Biomass (wood, biogas) 0.5 Waste heat (sewage, industry, etc.) 0.6 Fossil fuels 1.0 and Electricity 2.0.

Note: Cubic metres may not be an appropriate unit for comparison between materials (not a functional unit).

EPDs and Forest Certification

The wood industry has been a leader in the development of EPDs. An EPD is a standardized, third-party verified label that communicates the environmental performance of a product, is based on the LCA, and is applicable worldwide.

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

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

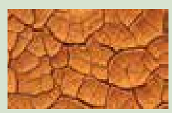
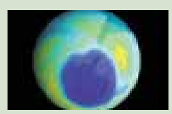
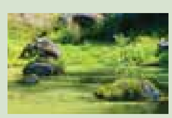
EPDs for wood products are available from the American Wood Council (www.awc.org) and Canadian Wood Council (www.cwc.org) at http://www.awc.org/greenbuilding/epd.php

Additional EPDs for other wood products (e.g. Western Red Cedar) are available from FPInnovations at https://fpinnovations.ca/ResearchProgram/environment-sustainability/epd-program/Pages/default.aspx

Impact Category Indicators Table from the Softwood Lumber EPD

The life cycle impact assessment (LCIA) results are calculated for impact category indicators such as global warming potential and smog potential. These results provide general, but quantifiable, indications of potential environmental impacts. The various indicators and means of characterizing the impacts are summarized in this table.

Impact Assessment Categories

Impact Category Indicators	Characterization Model
Global Warming Potential 	Calculates global warming potential of all greenhouse gasses that are recognized by the Intergovernmental Panel on Climate Change. The characterization model scales substances that include methane and nitrous oxide to the common unit of kg CO_2 equivalents.
Ozone Depletion Potential 	Calculates potential impact of all substances that contribute to stratospheric ozone depletion. The characterization model scales substances that include chlorofluorocarbon, hydrochlorofluorocarbon, chlorine, and bromine to the common unit of kg CFC-11 equivalents.
Acidification Potential 	Calculates potential impacts of all substances that contribute to terrestrial acidification potential. The characterization model scales substances that include sulfur oxides, nitrogen oxides, and ammonia to the common unit of H+moles equivalents.
Smog Potential 	Calculates potential impacts of all substances that contribute to photochemical smog potential. The characterization model scales substances that include nitrogen oxides and volatile organic compounds to the common unit of kg O_3 equivalents.
Eutrophication Potential 	Calculates potential impacts of all substances that contribute to eutrophication potential. The characterization model scales substances that include nitrates and phosphates to the common unit of kg N equivalents.

Wood: A Carbon-neutral Building Material

- Manufacturing of wood products requires less total energy, and in particular less non-renewable (fossil) energy, than the manufacturing of most alternative materials.
- The drying process accounts for most of the energy used in the manufacture of wood products. Wood processing residues (such as sawdust) are commonly used to fuel the drying, avoiding depletion of fossil fuels.
- When sustainable forestry is practiced, trees, and the carbon they contain, are replenished as they are harvested. Carbon is obtained from atmospheric CO_2 via photosynthesis, becoming part of wood as a tree grows in height and diameter.
- Timber-based building products continue to store carbon absorbed during the tree's growing cycle for as long as they are in use.

The capacity of trees to absorb and store carbon can be factored against the carbon emissions incurred during drying, processing, and transporting wood products. The result is a very low carbon building material.

What to Ask Suppliers

Encourage product manufacturers to perform life cycle assessments on their products and make the results available. Ask product reps for LCA data and LCA-based EPDs for wood and all other products on the bill of materials. If lacking, encourage sourcing from manufacturers that do provide such information. Ask or consider key questions about the data that are provided in order to assess the reliability and applicability to design decisions.

Examples of such questions include:

- What are the sources of the data? How much is based on primary information obtained directly from the operations, as opposed to databases of industry-average data? Of the industry average data, is it regionally specific (U.S. as opposed to Europe) and fully transparent to users or peer reviewers?
- What assumptions are included about the functional unit and the service life of the product(s) in question? Do these correspond to the project at hand?
- What is included in any life cycle assessment or life cycle cost calculation? Sometimes, certain materials or components are excluded, e.g., the resin in a composite wood product.
- What is assumed about the products' maintenance requirements and/or impacts on building operations?
- Do the impact categories included in the results capture the important information, or might the results be skewed by leaving out key categories?

Resources

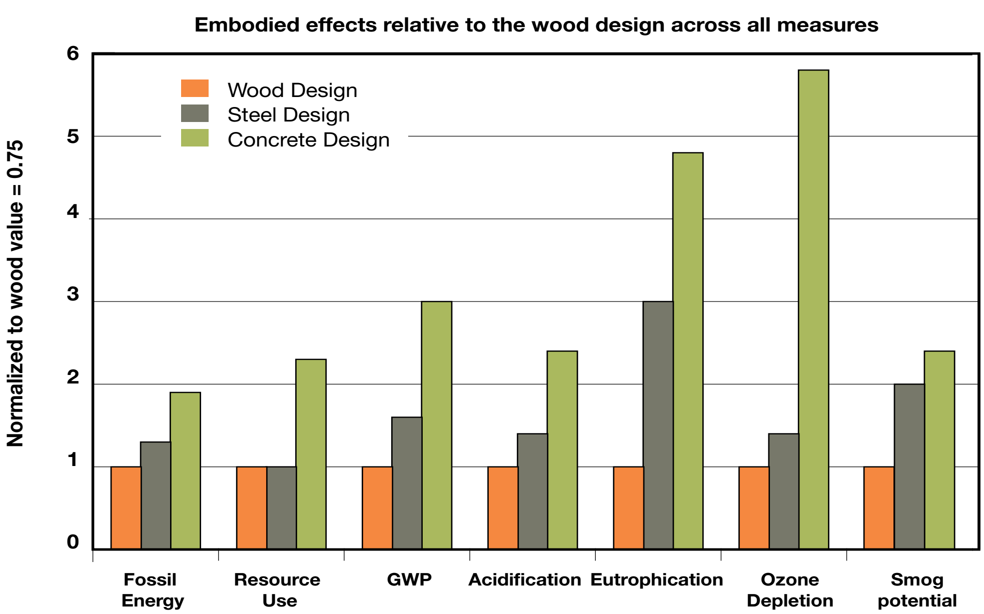
Whole Building Design Guide—Life Cycle Tools www.wbdg.org/tools/tools_cat.php?c=3 : developed by the National Institute of Building Sciences in the United States, provides a variety of life cycle cost and assessment tools.

European Commission, Life Cycle Thinking www.eplca.jrc.ec.europa.eu/ home of the International Reference Life Cycle Data System which seeks to identify improvements to goods and services in the form of lower environmental impacts and reduced use of resources across all life cycle stages. The site includes a handbook and information about the European Platform on Life Cycle Assessment and the European Reference Life Cycle Database (ELCD core database v2 with 300+ processes).

United Nations Environment Program, Life Cycle Initiative www.lifecycleinitiative.org/ : aims to bring science-based life cycle approaches into practice worldwide.

Athena Guide to LCA Credits In Green Building Programs www.athenasmi.org/resources/lca-credits/

Dovetail Partners Inc., Life Cycle Assessment & Environmental Product Declarations, www.dovetailinc.org/programs/responsible_materials/lca_and_epds



Life Cycle Assessment Tools

LCA software offers building professionals powerful tools for comparing products and calculating the lifetime impacts of building products or assemblies. Data gathered via LCA are of particular interest to long-term building investors who are concerned about the overall impacts of their buildings and about protecting the value of their assets.

A summary of tools is available on the website of the United States Environmental Protection Agency (http://www.epa.gov/nrmrl/lcaccess/resources.html). The most popular are listed below.

For General Building Professionals

- **Athena EcoCalculator for Assemblies and Impact Estimator for Buildings www.athenasmi.org/our-software-data/overview/ :** free inventory data tool for comparing assemblies or whole buildings, based primarily on the widely acclaimed US Life Cycle Inventory Database and published Canadian data.
- **BEES www.nist.gov/el/economics/BEESSoftware.cfm :** easy-to-use, US-based, free tool for product-to-product comparisons; based on proprietary, unpublished data.
- **ENVEST www.envestv2.bre.co.uk/ :** UK-based, life cycle assessment-based building design tool. It addresses only the whole building, and provides results in highly summarized "ecopoints."
- **Forest Industry Carbon Assessment Tool (FICAT) www.ficatmodel.org/landing/index.html :** available for download free of charge, calculates carbon footprints of the effects of forest-based manufacturing activities on carbon and greenhouse gases along the value chain.

For Life Cycle Assessment Practitioners

- **GaBi www.gabi-software.com :** a tool from Germany, comprised of primarily European data.
- **SimaPro www.pre.nl/simapro :** a tool from the Netherlands; includes a comprehensive suite of databases for building materials applicable to the United States, Japan, and various European countries.

Comparing Environmental Impact of a Wood, Steel and Concrete Home

In this graph, three hypothetical commercial buildings (wood, steel, and concrete) of identical size (40,000 sq ft) and configuration are compared. Assessment results are summarized into seven key measures covering fossil energy consumption, weighted resource use, global warming potential, and measures of potential for acidification, eutrophication, ozone depletion, and smog formation. In all cases, impacts are lower for the wood design. Source: Dovetail Partners using the Athena Eco-Calculator (2014)