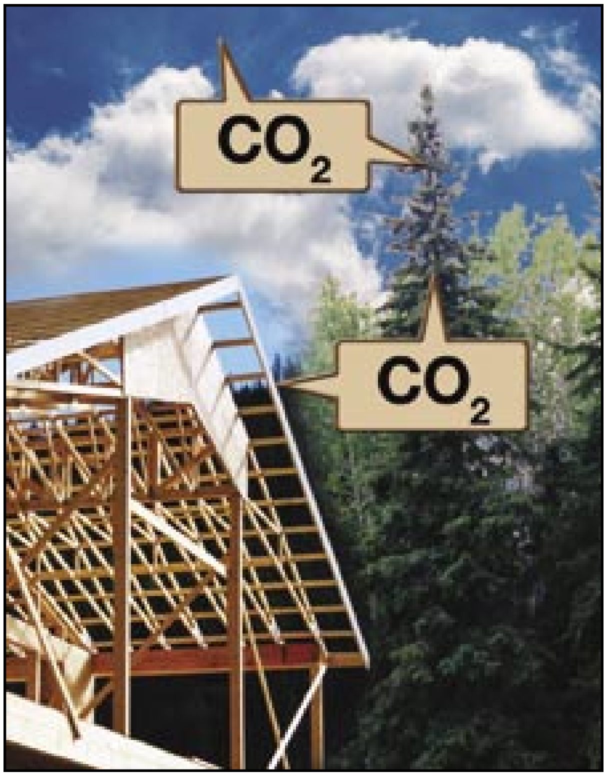
SUSTAINABLE DESIGN AND WOOD

A Wood-Frame Building Performance Fact Sheet



Wood framing achieves a comparatively minimal environmental footprint due to the relatively clean and low-energy manufacturing processes for wood construction products. In addition, continuous renewal of the forest paired with use of wood for long-lived products like houses and furniture helps mitigate the current imbalance in the earth's carbon cycle leading to global warming.

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Environmental awareness in building design, construction and operation is stronger than ever. But how can we meet the world's rapidly growing need for buildings and still be environmentally responsible? Although construction is never fully benign for the environment, designers and builders can make choices to minimise the impact. Wood plays an important part in sustainable design, as shown by scientific analysis.

Environmental impact of product selection

Buildings stress the planet in several ways. Depletion of natural resources, ecosystem disruption, air and water pollution, and generation of waste are just some of the undesirable side effects of building construction and operation. Many design decisions have an influence on a building's environmental footprint – but it can be difficult for an environmentally-conscious designer to wade through the confusing mass of "green" information.

Choosing construction products based on environmental impact requires an analysis process called life-cycle assessment (LCA). This is the internationally-accepted method for quantifying the total environmental effects associated with products: extraction of raw resources; product manufacture and transportation; product installation, use, and maintenance in a building; and ultimate disposal or reuse. This rigorous cradle-to-cradle calculation gives the only true picture of a product's environmental profile.

LCA is not yet incorporated in most current tools used to guide environmentally-conscious design decisions, such as various published "green product" directories, or the LEED™ rating system. In those cases, a subjective list of products or design strategies is supplied without scientific rationale – and it is likely that some of the recommendations sound better than they really are (1). Only non-biased LCA analysis, following international standard procedures, can help a designer make wise environmental choices.

LCA Tools

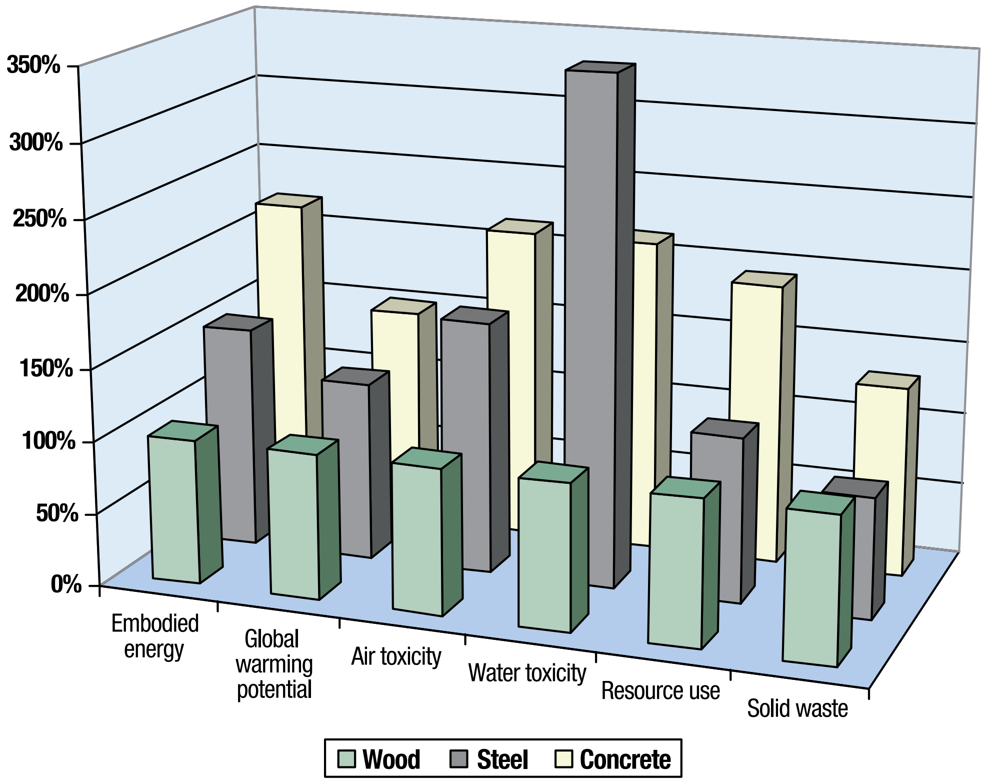
Until recently, the only software tools available for sustainable design were energy performance simulators. A rising interest in life-cycle assessment – and the emergence of several easy-to-use LCA tools – means designers can now take a more complete look at environmental impact. As with energy simulation, the use of LCA tools requires some investment by the designer in understanding the complexities of the subject (2). A typical LCA analysis would quantify the impact of design decisions across a varying set of environmental characterisation measures, usually including energy and raw material use, global warming potential, photochemical smog formation potential, acidification potential, ozone depletion potential, eutrophication potential and solid waste produced. The designer needs some knowledge of these environmental factors in order to interpret the LCA results. In addition, a designer needs to choose the right tool; LCA tools vary in their scope, geographic relevance, data transparency and data quality (3). But the resulting confidence in environmentally-sound product selections is well worth a designer's LCA preparation time. Several tools exist for various world regions; the ATHENA™ Environmental Impact Estimator (5) is the only North American software for life-cycle assessment of whole buildings.

Wood's environmental profile

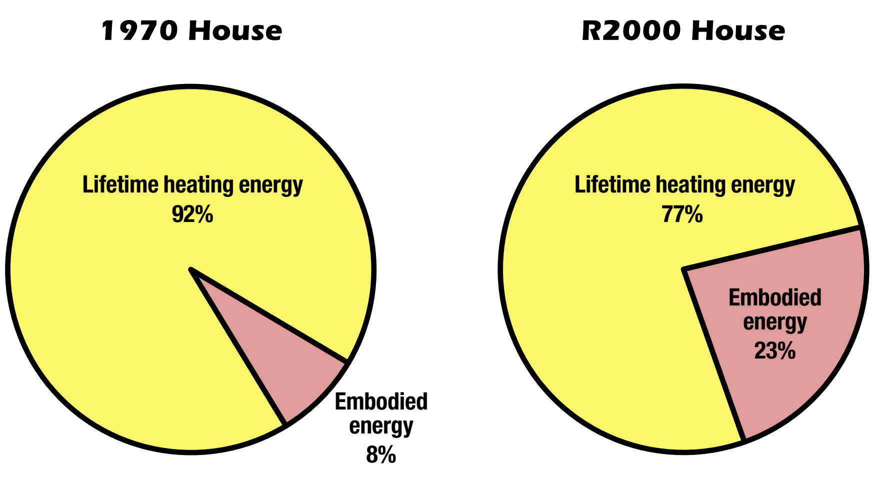
As a structural material, wood competes with various systems that use steel or concrete. How does wood measure environmentally against those other two materials? Because wood is uniquely characterised as renewable and easily transformable into standard construction products, we might expect wood to demonstrate a favourable environmental profile compared to competing materials. The Canadian Wood Council commissioned several LCA studies to rigorously quantify that comparison.

One of these studies is an evaluation of a typical North American house design, rendered in light-frame wood, light-frame steel, and insulated concrete forms (4). Each of the three houses was analysed for relative environmental impact. The wood house compared favourably to the steel and concrete houses in five of the six environmental measures calculated. The positive results reflect the relatively clean and simple manufacturing processes for wood products. Wood's only negative result, in solid waste generated, reflects our somewhat inefficient North American wood-frame building practices – because wood construction products have traditionally been plentiful and inexpensive, our use and waste recovery activities are often not optimised.

The environmental impact of wood construction has also been extensively studied in the United Kingdom by the Building Research Establishment (BRE). Active in the field of life-cycle assessment, BRE has developed environmental profiles of construction materials, a guide for product selection, and the LCA software tool ENVEST. BRE has concluded that building elements containing wood are often environmentally preferable to alternatives (6). The building environmental rating system BREEAM, developed by BRE and widely used in the U.K., awards credits for many wood assemblies (7). The BRE approach heavily weights climate change relative to the other environmental factors measured, which contributes to wood's attractive environmental profile.



Environmental impact relative to a typical wood-frame home (the 100% baseline) is shown for an equivalent house in light-gauge steel and an equivalent in insulated concrete forms (4). Data addresses the life-cycle portion from resource extraction through construction and does not include environmental impacts of building occupancy and demolition.



Operating versus embodied energy consumption for a typical 1970s North American wood-frame home and for a similar home designed to R-2000 standards, a Canadian program for energy efficiency. The climate is Ottawa and the life span is 30 years. This data was calculated using the HOT2000™ energy simulation software and the ATHENA™ Environmental Impact Estimator (5). In a milder climate, the embodied energy portion would be even larger.

Embodied Energy vs. Operating Energy

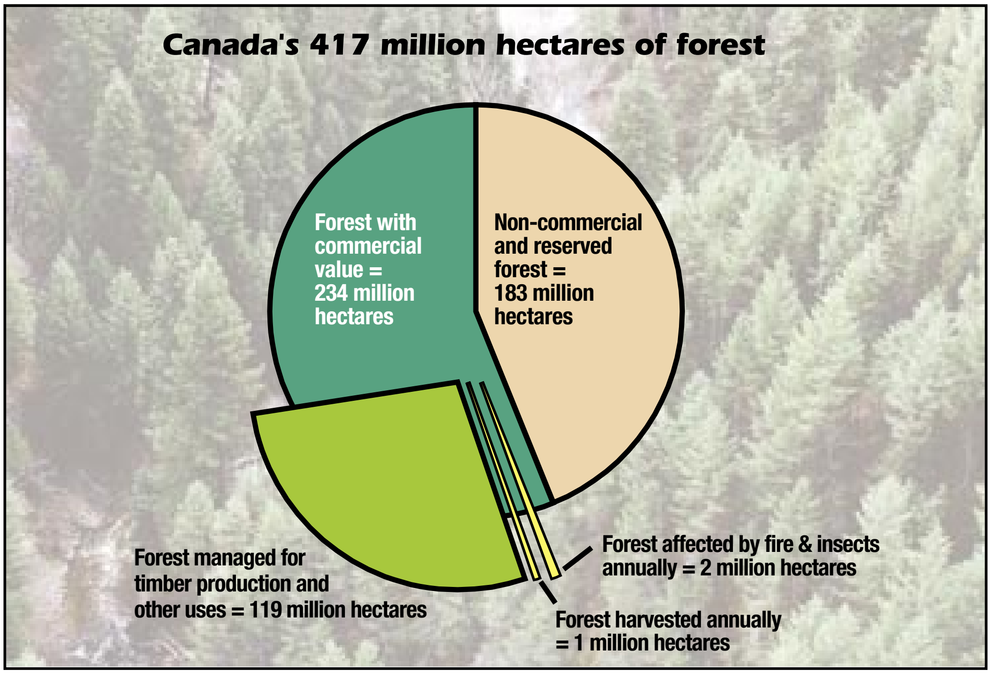
Energy use and associated greenhouse gas emissions (due to combustion of fossil fuels) are typically considered the most important environmental effects of a building. Buildings are substantial energy consumers with long lifetimes, thus we're usually most concerned about energy and emissions due to operation of the building. Energy consumed during product manufacturing and construction (embodied energy of the building) and the associated emissions are typically far smaller than operating energy – except in an energy-efficient building. As average operating energy for buildings goes down, the embodied portion of the equation goes up. Energy isn't the only important embodied effect. Some environmental impacts, such as toxic releases to water, are almost entirely a function of product manufacturing. Wood construction products typically score well in all embodied effects.

Recycled vs. Renewed

Recyclability and recycled content are important, especially for products made out of non-renewable resources. Recycling helps reduce landfill burdens, reduce the effects of resource extraction and can, in some cases, reduce a product's embodied energy. However, recycling doesn't necessarily result in reduced total environmental impact.

Most guidelines for green design presume that all recycled-content products are environmentally preferable over their virgin-content alternatives. Such a determination cannot be made in the absence of a standard life-cycle assessment for each product. Indeed, a recent study for NIST evaluating the LEED™ rating system discovered that points awarded for recycled content are invalidated by life-cycle assessment (8). For example, a virgin-content product using renewable materials may well be the better environmental choice than one with recycled content.

The study notes that steel in particular may be inappropriately advantaged in the credit structure of LEED™, which favours high-cost materials with inherent recycled content. The study uses LCA to quantify the disproportionate value awarded to steel, especially compared to recycled concrete. Other LCA studies demonstrate that steel is not environmentally preferable to wood (4, 6). Steel making, even with high rates of recycled content, remains one of the most energy-intensive industries.



Source: Forest Products Association of Canada, using Canadian Forest Service Data (9).

What about the forest?

Canada's status as a world leader in responsible forestry provides peace of mind to users of Canadian wood products. Canada has maintained its vast forests (10% of the world's forest cover) while also providing a large portion of the world's wood products. Canada has almost 92% of its original forest cover, more than any other country (9). Canada also has the world's largest area of forest land protected from harvesting (10).

Nearly all forests in Canada are publicly-owned, which means they are highly regulated according to the full range of values associated with a forest. These regulations not only dictate the volume of wood that can be harvested – Canada harvests less than one-half of 1% of its commercial forest area each year, or one-quarter of 1% of its total forest area – but also how quickly those sites must be regenerated, the use of buffer zones along waterways to prevent erosion and maintain water quality, the preservation of specific wildlife habitats, the involvement of local stakeholders, and much more (11). Canada's foresters and biologists are caretakers of entire ecosystems, with high priority given to the maintenance of biodiversity.

Largely due to climate, trees in most regions of Canada grow slowly – many would be called "old-growth," although this is a term without universal definition. Concerns about old-growth are well-intentioned but often misguided. The health and value of a forest ecosystem cannot be measured simply by age of its trees. Natural forests are in constant states of renewal – today's trees replace the ones before them, and so on. In all commercial forests across the country, forest managers are responsible for maintaining a good distribution of older and younger stands, as trees of all ages have important roles to play in sustaining biodiversity.

Another misunderstood aspect of silviculture is clear-cutting. The appearance of a fresh clear-cut, while unsightly to untrained eyes, is no indicator of the ecological impact of logging. Harvesting methods are carefully selected depending on the tree species, the soil and terrain, wildlife habitat and the conditions needed to renew a healthy forest (12). In forestry operations around the world, the environmental footprint of harvesting techniques is frequently challenged, leading to constant improvements as new knowledge about forest sustainability is developed (13).

With some of the strictest regulations on forest renewal, Canada is at no risk of deforestation. Still, some wood users are concerned about the state of forests around the world, and they may seek assurances that wood products come from certified forests. Certification is about providing evidence, through third-party independent verification, that forest management meets economic, social and environmental criteria. Certification also involves a commitment to continual improvement in forest management practices. So far, no other structural materials are expected to demonstrate this level of accountability.

A substantial proportion of Canada's forests have undergone certification under one of the forestry-specific standards, or registration under the general ISO 14001 standard for environmental management (14). Standards such as those established by the Canadian Standards Association (CSA), the Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC) vary in approach but all have the same objective – to promote sustainable forest management. Canada has been one of the most proactive countries in the world in its promotion of certification as a means to demonstrate forest stewardship. But neither certification standards nor chain-of-custody audits are an indicator of full environmental impact of wood products – only LCA analysis provides a comprehensive environmental picture.

Forestry and climate change

Atmospheric carbon dioxide (CO_2) is currently the most important contributor to the greenhouse effect and climate change. Trees capture CO_2 from the atmosphere by photosynthesis. In forests, the carbon thus captured is sequestered in living trees, in the litter and in soils. Forests also lose carbon to the atmosphere through the decomposition of their litter and fallen trees, and through forest fires. Forests, and man's impact on their extent, growth and use, play an important role in global warming.

A young, actively growing forest removes more CO_2 from the atmosphere than it releases through respiration and decay – it's a carbon sink. An old, stagnating forest has a low rate of growth and may be releasing as much CO_2 to the atmosphere as it absorbs. This forest is carbon-neutral, but contains a much larger stock of carbon than the younger forest (15). A large disturbance, such as an insect infestation or especially a fire, turns a forest into a net source of carbon to the atmosphere. In such cases, the older the forest, the more carbon is released.

Forests hold more carbon per unit area than almost any other type of land cover. Over the past century, deforestation – conversion of forests to farmland or other uses – has produced over one-third of all man-made CO_2 emissions (16). Current deforestation, mostly from tropical regions, still accounts for about 20% of all anthropogenic CO_2 emissions (17). Clearly, the maintenance of a productive forest is an attractive alternate to deforestation from a climate change and environmental perspective.

The development of an industrial forestry base and the sustainable management of forest resources have several benefits to climate change. Forest management provides an economic incentive against deforestation. Production of solid wood products results in the storage of a portion of the trees' carbon in another long-term storage medium (a house or furniture, for example). Forest regeneration ensures that the carbon-absorbing role of the forest is preserved. Energy generation from wood residues reduces the need for fossil fuels. Sustainable forestry is thus regarded as a simple and highly cost-effective way to mitigate the greenhouse gas emissions of other industries, especially in countries where large scale deforestation is an issue.

Canada's responsible forest stewardship helps offset deforestation in other parts of the world. And the widespread use of wood as a construction material also has global warming benefits by sequestering some of the CO_2 those trees absorbed. A typical 216 square meter (2400 square feet) wood-frame house is holding 28.5 tonnes of carbon dioxide. This is equivalent to seven years of emissions from a small, light-duty car.

Room for improvement

Wood's low-impact environmental profile has been demonstrated, but what about the role of wood construction products in the 3Rs of conservation? The low cost of lumber generally doesn't provide a strong financial incentive for conservation, but this may be changing.

Reduce

Standard practice for residential wood framing is less efficient than it could be. Common examples are structural members oversized for their loads, window and door openings not optimally aligned with the framing module, and unnecessary framing elements. An increased up-front investment in architectural and engineering time, along with the use of structurally efficient elements like trusses, can result in net savings to the builder and a significant reduction in wood materials used (18). "Advanced framing" has begun to catch the interest of builders.

At the manufacturing end, numerous technological innovations that get more product out of each log continue to emerge. For example, improvements in sawmilling have reduced wood waste dramatically. Kiln-drying optimisation has cut back on the energy used to produce dry lumber. And engineered wood products are widely recognised as highly efficient in use of material while additionally incorporating wood residuals recovered from the manufacturing process as well as wood from fast-growing and under-utilised tree species.

Recycle

Building-related construction and demolition waste is a substantial load on waste management systems, and recovery is a challenge for all materials. Estimates based on 1996 data indicate a total of 136 million tons of building debris are generated in the United States each year, 25% of which is recovered for recycling and 75% either combusted or sent to landfill (19).

Wood recovery for recycling is improving, with a rapid growth in the number of companies processing recovered wood in recent years. Wood waste can be remanufactured into high-value composite products like medium density fiberboard (MDF), finger-joined lumber and wood/plastic composite lumber. Some wood users may not realise that these wood products often contain a high degree of recycled content. Wood waste is also chipped into mulch, animal bedding, and other low-grade uses, or burned as useful fuel.

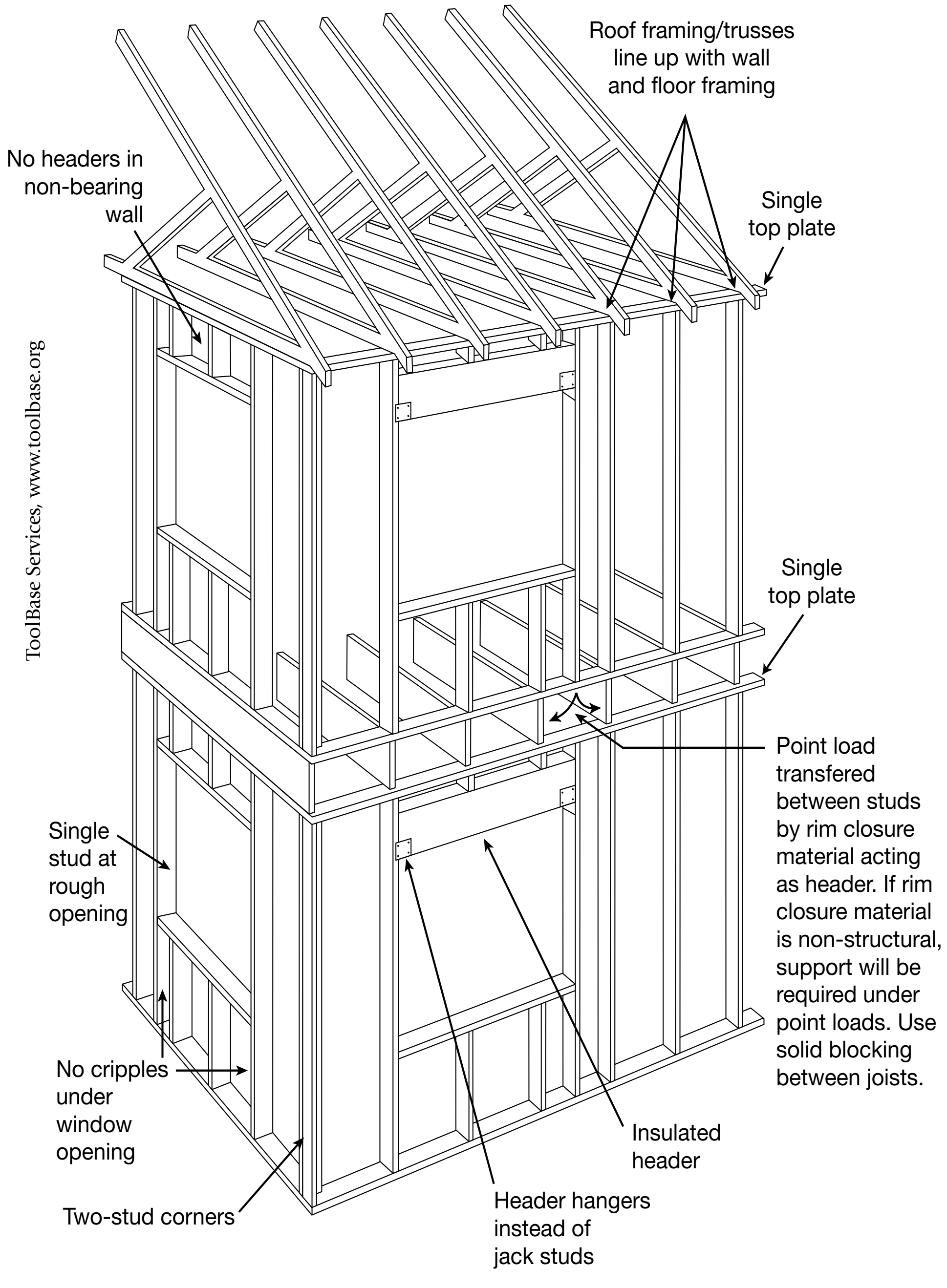
Wood recovery at the industrial end is good – wood product manufacturers capture 94% of their wood waste (20). However, wood recovery from the municipal waste stream (5.5% of which is solid wood, not including yard waste) and the construction and demolition waste stream (about 40% wood) is less effective. Of the solid wood in municipal waste, 5% is recycled or composted, 26% is burned for energy recovery, and 69% is sent to landfills. About two-thirds of that landfilled wood is estimated to be suitable for recovery (21).

Similarly, construction waste wood has good potential for recovery improvement. About 75% of this wood is still available for recovery; 25% is already recovered, burned or is not usable (21). Construction waste presents good recovery opportunities because the material is generally clean and easy to separate.

Demolition waste is more difficult – potentially recoverable materials are highly mixed and possibly contaminated with other materials. Only 34% of demolition wood waste is estimated as still available for recovery; 66% is already used, burned, or – most frequently – considered unusable (21). Standard demolition techniques break up and mix building products too much for cost-effective recovery. One solution is "deconstruction" – selectively dismantling a building in order to carefully remove re-usable or recyclable products.

Re-use

Wood can be reclaimed from decommissioned buildings and re-used directly, a niche activity which is increasing due to strong market interest in salvaged large-dimension timbers (22). In addition, there is a large and as-yet relatively untapped store of standard lumber in the ageing North American residential housing stock. But widespread recovery will require that the deconstruction and wood re-grading process becomes easier and more financially attractive.



Some possible wood optimisation measures as suggested by the U.S. National Association of Home Builders (18) are shown. Known as advanced framing, or optimum value engineering, this careful approach to wood-frame design may result in wood and labour savings as well as reduced home heating and cooling costs due to less thermal bridging. Applicability for a specific project will depend on design circumstances, and special consideration may be required where there are high wind, seismic or snow loads.

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Forintek Canada Corp.

Forintek is Canada's wood products research institute. Established as a private, not-for-profit corporation in 1979, Forintek is an amalgamation of two former public laboratories whose history dates back to 1913. To this day, Forintek continues to provide leading-edge technical support to the solid wood products industry. As part of its broad program, Forintek has been actively performing and supporting research in sustainable materials and life-cycle assessment since 1990. For more information, visit www.forintek.ca.

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Canada Mortgage and Housing Corporation is the Federal government's housing agency. For over 50 years, CMHC has been helping provide Canadians with housing quality, affordability and choice. CMHC is also the Canadian housing industry's export partner, bringing Canadian expertise to foreign markets. In addition, CMHC is Canada's largest publisher of housing information. Visit www.cmhc-schl.gc.ca.

Canadian Wood Council / Conseil canadien du bois

The Canadian Wood Council (CWC) is the national federation of wood product associations. Through its Member Associations, the Council represents approximately 1,200 Canadian manufacturers of lumber, plywood, oriented strandboard, treated wood, glued laminated lumber, engineered wood products and trusses. Its mission is accomplished by working with building codes and standards and by developing and communicating technical information to architects, engineers and builders. Visit www.cwc.ca.

Forest Products Association of Canada / Association des produits forestiers du Canada

The Forest Products Association of Canada (FPAC) is the voice of Canada's wood, pulp and paper producers nationally and internationally in government, trade and environmental affairs. FPAC represents the country's largest producers of pulp, paper and wood products, and its members have responsibility for over 75% of the working forests in Canada. We provide an active forum for advancing ideas and issues of importance to the Canadian forest products industry and the 1,200 communities it sustains across the country. With the help of member companies, FPAC develops programs to promote Canada's leadership in sustainable forest management and environmental stewardship. FPAC builds on almost 100 years of experience as the former Canadian Pulp and Paper Association (CPPA). Visit www.fpac.ca.

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