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Decarbonization

CONSIDERING THE EMBODIED CARBON IN BUILDINGS

Reducing embodied carbon is our new priority!

LOUIS POLIQUIN, M. SC.
DIRECTOR, CECOBOIS

The construction sector is known to be a major emitter of GHG. According to a report by the United Nations Environment Programme (UNEP), this sector alone accounts for 37% of global GHG emissions, which is why many countries are stepping up their efforts to decarbonize their buildings sector.

For the most part, these efforts focus on reducing emissions linked to building operation, such as heating and lighting. Today, however, we are becoming aware that GHG emissions resulting from the manufacture of materials, i.e., embodied carbon, weigh heavily in the carbon balance of buildings. As energy performance improves and cleaner energy sources are used, embodied carbon is playing a greater role. This is particularly true in Quebec, where the main source of energy is hydropower. In our current energy context, embodied carbon can account for up to 75% of a building's carbon impact over its entire life cycle.

Against this backdrop and in view of the climate emergency, the means deployed to reduce the carbon footprint of buildings must go beyond improving energy efficiency and include reducing embodied carbon. That's why some countries like France, and cities like Toronto and Vancouver, have decided to regulate it.

In this issue of the Build with wood journal, we take a look at the issue of embodied carbon. Together, our collaborators discuss the role of embodied carbon in the proportion of global GHG emissions and in the carbon emissions associated with buildings. They present various initiatives being implemented by professionals, research centres and governments alike here and elsewhere to move in the direction of carbon neutrality in the construction sector. One thing is clear in this dynamic: wood and bio-based insulation are key, given their low carbon footprint.

Happy reading!

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NEWSLETTER

FRONT COVER
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THE MANI-UTENAM CULTURAL CENTRE TIMBER STRUCTURE

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Decarbonization

CONSIDER THE EMBODIED CARBON IN BUILDINGS

In the face of the climate emergency, Canada has set itself ambitious targets to reduce its carbon footprint. Canada's 2030 Emissions Reduction Plan: Clean Air, Strong Economy calls for an emissions reduction target of 40% to 45% below 2005 levels, putting us on a path to achieve net-zero emissions by 2050. In order to reach their objective, Canada and Quebec will have to tackle all business sectors, including buildings, a significant contributor to greenhouse gas (GHG) emissions.

GHG emissions from buildings in Canada account for 13% of the country's total emissions.[1] This figure takes into account emissions linked to **operational energy**, including those from electricity generation. However, emissions associated with materials manufacturing and construction processes are still overlooked and not highlighted in these national statistics. Yet, the carbon from the manufacture of building materials can no longer remain invisible, particularly in the context of Quebec, which has already made visionary efforts to decarbonize its energy sector thanks to hydropower.

Globally, statistics that include embodied carbon show that the building sector is responsible for 37% of global anthropogenic GHG emissions, making it the third-biggest contributor.

Today, stakeholders from the construction industry are responsible for doing their utmost to reduce the sector's emissions by imposing a low-carbon policy on their buildings, including impacts from the choice of materials.

"IN QUEBEC, EMBODIED CARBON REPRESENTS A HIGHER PORTION OF THE CARBON FOOTPRINT OF BUILDINGS AND IS BECOMING A REDUCTION PRIORITY."

At the WoodRise event held in Bordeaux in October 2023, several representatives of the Quebec delegation learned about the importance of including embodied carbon in the decision-making process of European professionals and the tools available.

Definition

Operational energy: Operating energy is the energy used during the occupancy phase of the building life cycle for heating and cooling, etc.

What is the embodied carbon of buildings?

Embodied carbon is the total amount of GHG emissions due to the building materials in a building. When considering the whole life cycle of a building, embodied carbon considers emissions occurring at various stages including resources acquisition, transportation, manufacturing, maintenance, replacement , refurbishment, and the end-of-life of the building materials. Most of these impacts occur at the very beginning of the building's life cycle. Therefore, the choice of materials at the design stage is critical to reducing a building's environmental impact.

Canada and Quebec agree with Paris

The Paris Agreement, written within the framework of the COP21, aims to limit warming to below 2°C while continuing efforts to limit the rise to 1.5°C. Under this agreement, Canada has committed itself to reducing its emissions by 40% below 2005 levels and included this objective in its 2030 Emissions Reduction Plan, in addition to achieving net-zero emissions by 2050. Although Quebec is not bound by the Paris Agreement, in its 2030 Plan for a Green Economy (2030 PGE), it pledged to reduce its GHG to 37.5% below 1990 and achieving carbon neutrality by 2050.

In 2021, according to the National Inventory Report: Greenhouse gas sources and sinks in Canada[2], the building sector contributed 13% of total Canadian emissions, with 87 $MTCO_2e$. These emissions have stabilized since 2005 (85 $MTCO_2e$), although they are higher than in 1990 (72 $MTCO_2e$). In Quebec, energy measurements taken in recent years have helped to reduce emissions from residential construction by 45.6%, dropping from 7 to 3 $MTCO_2e$. In comparison, emissions from commercial and institutional buildings fell only modestly by 4.2%, from 4.3 to 4.1 $MTCO_2e$. However, statistics for Canada and Quebec demonstrate that GHGs related to the building sector only take into account the impact of direct energy consumption in buildings (heating and lighting).

1. Canada's Report of the Standing Senate Committee on Energy, the Environment and Natural Resources

2. Environment and Climate Change Canada. 2023. "National Inventory Report 1990–2021: Greenhouse gas sources and sinks in Canada." Canada's submission to the United Nations Framework Convention on Climate Change. publications.gc.ca/collections/collection_2023/eccc/En81-4-2021-1-eng.pdf

Taking action against climate change

According to the Intergovernmental Panel on Climate Change (IPCC), to ensure that the rise in temperature does not exceed 1.5°C, the concentration of CO_2 in the atmosphere must remain below 430 ppm (particles per million). Yet in 2013, the Mauna Loa station in Hawaii was already recording 393 ppm, and 10 years later, in autumn 2023, the concentration had reached 418 ppm. At this rate, it will take less than 10 years to reach the 430 ppm mark, especially as the increase is not linear. Last spring, the World Meteorological Organization (WMO) reported that the global mean temperature had risen to 1.15°C in 2022, with a 66% probability of exceeding 1.5°C by 2027.

In addition to energy efficiency targets, it must be made mandatory to reduce the GHGs associated with the manufacturing of building materials. Increasing the use of wood in commercial and institutional buildings could help in the fight against climate change and guide Quebec toward carbon neutrality. This opportunity must be seized.

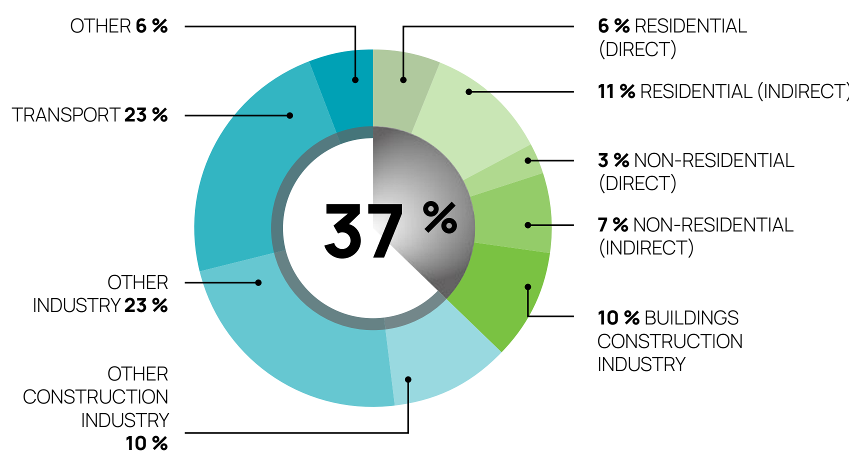
This is one of the avenues examined by the 2023 PGE, which intends to improve the energy efficiency of buildings, in addition to using low-carbon materials such as wood. This concept has been confirmed in the Quebec context by a number of studies[3] demonstrating that replacing steel or concrete with wood can reduce GHG emissions by 25% to 40%. Yet, currently, only 35% of industrial, commercial, institutional and multi-residential housing starts use wood as a structural material. However, over 80% of non-residential buildings could be built with wood while still complying with current building codes.

Wood, a carbon-neutral material

In an effort to reduce GHG emissions from buildings, the focus is often on increasing energy efficiency, while the carbon footprint of building materials is overlooked. The Global Alliance for Buildings and Construction (GlobalABC) reviewed GHG emissions from the energy consumption in buildings, distinguishing between the construction phase (manufacture of materials, transportation and construction) and the building operational phase. GlobalABC reported that embodied carbon accounts for a third of GHG emissions. That is why building with low-carbon materials is a major driver in reducing GHG emissions from buildings, i.e. **carbon footprint**. In this sense, the Global Alliance for Buildings and Construction advocates an approach based on the complete building life cycle and a shift to low-carbon, bio-based materials.

Among the solutions for mitigating GHG emissions from buildings put forward by the Intergovernmental Panel on Climate Change (IPCC), two suggest turning to wood: storing carbon in long-lasting wood products and using wood in order to substitute high carbon footprint materials.

Buildings and construction's share of global energy-related CO_2 emissions in 2020



CONSTRUCTION INDUSTRY: represents the share of the manufacturing industry dedicated to the production of building materials, such as steel, cement and glass.

Source : GlobalABC, 2021

Definition

Direct emissions: Emissions from sources that are owned or controlled by the building owner.

Indirect emissions: missions that are tied to activities being sourced from outside the building

Carbon footprint: A carbon footprint is an indicator that measures the GHG emissions released by a particular activity. It is expressed in CO_2e.

3. RODRIGUES VIANA, Luciano. ZAGA MENDEZ, Alejandra. BISSONNETTE, Jean-François and BOUCHER, Jean-François. 2022. “En construction, mieux vaut préconiser le bois pour réduire l'empreinte carbone des bâtiments.” [It is preferable to use wood in construction to reduce the carbon footprint of buildings] [French only]. The Conversation, June 27, 2022. theconversation.com/en-construction-mieux-vaut-preconiser-le-bois-pour-reduire-lempreinte-carbone-des-batiments-180752

Impact of materials?

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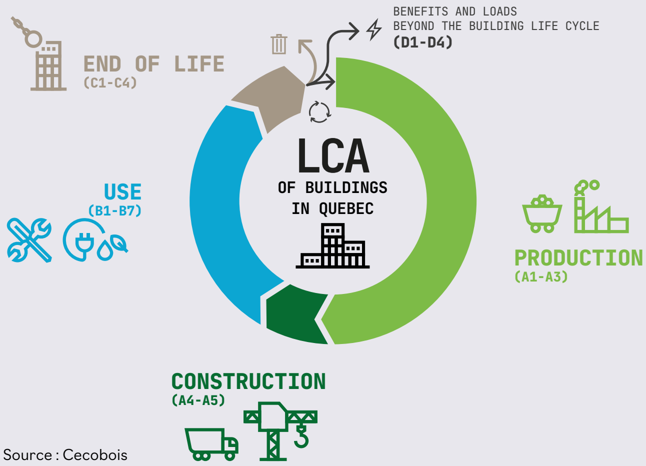
Life cycle assessment (LCA) has become the tool of choice for gaining a better understanding of the various environmental impacts of buildings, including their carbon footprint.

Since January 1st, 2023, in France, the new requirements introduced by the Environmental Regulation RE2020 make LCAs mandatory for construction permits for residential buildings.

A Life cycle assessment (LCA) evaluates the potential impacts from all stages of a building's life cycle.



Source : Cecobois

As described by the International Reference Center for Life Cycle Assessment and Sustainable Transition (CIRAIG), LCA is a methodology for assessing the potential environmental and social impacts and costs of all stages in the life of a product or service. This includes stages from the extraction of raw materials to end of life (disposal or recycling), including the processing, manufacturing, distribution, use, repair and maintenance of materials.[4]

The CIRAIG, based at Polytechnique de Montréal, has been using LCA for over 20 years to quantify the environmental impact of various products.

LCA methodology is governed by the principles, requirements and guidelines of ISO standards 14040 and 14044. These general standards apply to carrying out all LCAs, whether you are evaluating a light bulb, a vehicle or a building.In the case of an LCA of a complex system like a building, additional standards dictate the methodology to be used. In Europe, European standard EN 15978 defines the phases of a building's life cycle. In North America, the National Research Council of Canada (NRC) has published guidelines with the aim ofproviding a framework for interpreting standards in the building sector.[5]

Whole building LCA makes it possible to quantify the various environmental impacts of a building over its entire life cycle, from the extraction of materials to its construction and use, and up to the end of its life cycle. Therefore, GHG emissions are one of the indicators established during an LCA

In Quebec, government programs such as the Programme d'amélioration et de construction d'infrastructures municipales (PRACIM), the Programme d'innovation en construction bois (PICB) and the Société québécoise d'infrastructures (SQI) encourage designers to use tools to estimate the GHG emissions generated by building materials..

4. International Reference Center for Life Cycle Assessment and Sustainable Transition (CIRAIG.org)

5. BOWICK, Matthew. O'CONNOR, Jennifer. SALAZAR, James. MEIL, Jamie. COONEY, Rob. 2022. "National guidelines for whole-building life cycle assessment." National Research Council of Canada. Construction. doi.org/10.4224/40002740

Building sector emissions: embodied and operational carbon

Numerous LCAs in the scientific literature have made it possible to understand how each phase of the building life cycle contributes to environmental impacts, particularly GHG emissions. These studies focus on **operational carbon**, i.e., the carbon emitted during the use of the building, including heating, and **embodied carbon**, i.e., the carbon emitted mainly during the manufacturing of building materials.

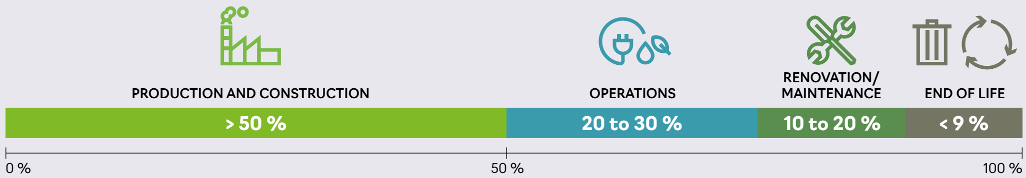
To date, strategies and measures to reduce GHG emissions have targeted mainly building operational energy use, commonly referred to as operational carbon.

Les moyens préconisés pour réduire ces émissions portent principalement sur l'amélioration de l'efficacité énergétique et la conversion des

The preferred means to reduce these emissions mainly involve improving energy efficiency and converting heating energy sources to greener energies, such as hydropower. Since numerous policies and certifications have significantly helped improve the energy efficiency of buildings in recent decades, the impact of operational carbon is trending down.

Yet, emissions from the manufacturing of materials used in the construction and renovation of buildings, i.e., embodied carbon, account for an ever-increasing proportion of GHG emissions associated with the construction sector.

Contribution of buildings' life cycle stages to total environmental impacts analyzed in the context of a low-carbon energy mix.[6]



Source : Graphic adapted from Lessard et al., 2017[6]

In short, LCAs make it possible to...

- quantify environmental impacts and identify the hot spots life-cycle phases in order to support strategic decisions or guide design;
- identify alternative scenarios using low-carbon building materials;
- ensure a holistic view of the building to avoid the transfer of environmental impacts elsewhere in the life cycle (between life-cycle stages);
- introduce eco-design principles into a company.

Definition

Operational carbon: Operational carbon is the carbon emitted during building use, including heating.

Embodied carbon: Embodied carbon is the total of GHGs associated with building materials over the entire life cycle.

Eco-design: Eco-design is an approach that aims to design products by reducing or preventing environmental impacts throughout it's life cycle.

6. Lessard, Yannick; Anand, Chirjiv Kaur; Blanchet, Pierre; Frenette, Caroline and Amor, Ben (2017) LEED v4: Where Are We Now? Critical Assessment through the LCA of an Office Building Using a Low Impact Energy Consumption Mix. Journal of Industrial Ecology. Vol. 22, Issue 5, pages 1105–1116. doi.org/10.1111/jiec.12647

In its 2020 report, GlobalABC stated that the production of construction materials for buildings and infrastructure is responsible for 20% of global energy-related GHG emissions.[7]

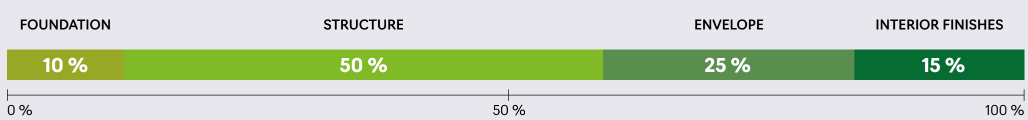
Why do we talk about embodied carbon?

The carbon impact of buildings on a global level is analyzed by the Global Alliance for Buildings and Construction (GlobalABC), which was founded at COP21 and hosted by the United Nations Environment Programme. In its 2020 report, GlobalABC said that the production of construction materials for buildings and infrastructure accounts for 20% of global energy-related GHG emissions.[7] According to the report, this 20% comes mainly from steel, cement and glass production. Concrete production alone accounts for around 8% of global CO_2 emissions. In the United States, the U.S. Environmental Protection Agency (EPA) reports that steel and cement production rank third and fourth among the country's biggest GHG emitters.[8]

A growing number of recent studies also show that embodied carbon represents a significant source of GHG emissions, particularly in regions with access to decarbonized energy, such as hydropower in Quebec.[9, 10, 11, 12, 13]

If we are to accelerate **decarbonization**, one way forward lies in replacing carbon-intensive materials with low-carbon materials such as **bio-based materials**. Toronto has become the first North American jurisdiction to limit embodied emissions from new municipal building construction. Several other regulatory initiatives are going forward including Vancouver's Climate Emergency Action Plan and Edmonton's LCA requirement for municipal building construction.

Building construction systems' contribution to GHG emissions[12]



Source : Graphic adapted from Lessard et al., 2017

Definition

Decarbonization: Decarbonization refers to all the measures taken to limit or reduce our carbon footprint.

Bio-based materials: Bio-based materials are materials derived from a renewable resource, whether plant, animal or mineral.

7. United Nations Environment Programme (2020). 2020 Global Status Report for Buildings and Construction: Towards a Zero emissions, Efficient and Resilient Buildings and Construction Sector – Executive Summary. https://wedocs.unep.org/20.500.11822/34572.

8. EPA (2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. U.S. Environmental Protection Agency, EPA 430-R-23-002.

9. Thormark C. The effect of material choice on the total energy need and recycling potential of a building. Building and environment. 2006 Aug 1;41(8):1019-26. https://doi.org/10.1016/j.buildenv.2005.04.026

10. P. Chastas, T. Theodosiou, D. Bikas, K. Kontoleon, Embodied Energy and Nearly Zero Energy Buildings: A Review in Residential Buildings, Procedia Environmental Sciences, Volume 38, 2017, Pages 554-561, ISSN 1878-0296, https://doi.org/10.1016/j.proenv.2017.03.123

11. Batsy, Dieudonné Romaric et Lavoie, Patrick. Évaluation des constructions à haute efficacité énergétique dans le contexte québécois. FPInnovations, 2019. https://cdn-contenu.quebec.ca/cdn-contenu/forets/documents/entreprises/RA_Etude4_NetZero.pdf

12. Lessard, Yannick; Anand, Chirjiv Kaur; Blanchet, Pierre; Frenette, Caroline and Amor, Ben (2017) LEED v4: Where Are We Now? Critical Assessment through the LCA of an Office Building Using a Low Impact Energy Consumption Mix. Journal of industrial Ecology. Journal of Industrial Ecology. Vol. 22, No. 5, pp. 1105-1116. https://doi.org/10.1111/jiec.12647

13. Röck, M. et al. Embodied GHG emissions of buildings: the hidden challenge for effective climate change mitigation. Appl. Energy 258, 114–107 (2020).

Tools for measuring embodied carbon

There are a number of tools available to model an LCA to assess the potential environmental impacts of a building. They differ in their complexity, the precision of their databases, their integration into design software and their acceptance into building certifications and environmental policies.

Generic tools such as SimaPro, Open LCA and GaBi make it possible to model LCAs on products from all business sectors, such as light bulbs, cars and buildings.

Other tools are specific to building design, such as Athena IE4B, OneClick LCA and TallyLCA. They take several life cycle stages and various environmental indicators into account.

Some of the environmental impacts of construction materials can also be found in an environmental product declaration (EPD). An EPD presents the results of an LCA carried out for a specific product.

Some tools focus on carbon by measuring GHG emissions. This is the case for GESTIMAT/GHGMAT, EC3 and EPIC. These tools calculate the carbon footprint of a construction project by multiplying the quantity of each material by a specific GHG emission factor for the entire building. The simplified approach of these tools makes them easy for professionals to use. They can be used to guide design choices or assess the carbon gains related to the choice of materials. In particular, GESTIMAT/GHGMAT makes it possible to quickly model certain building typologies in order to simplify the assessment of carbon in Québec/Ontario, which helps guide design through the use of a free, simple and transparent tool.

Types of methodology and examples of tools for assessing environmental impacts in the construction sector.

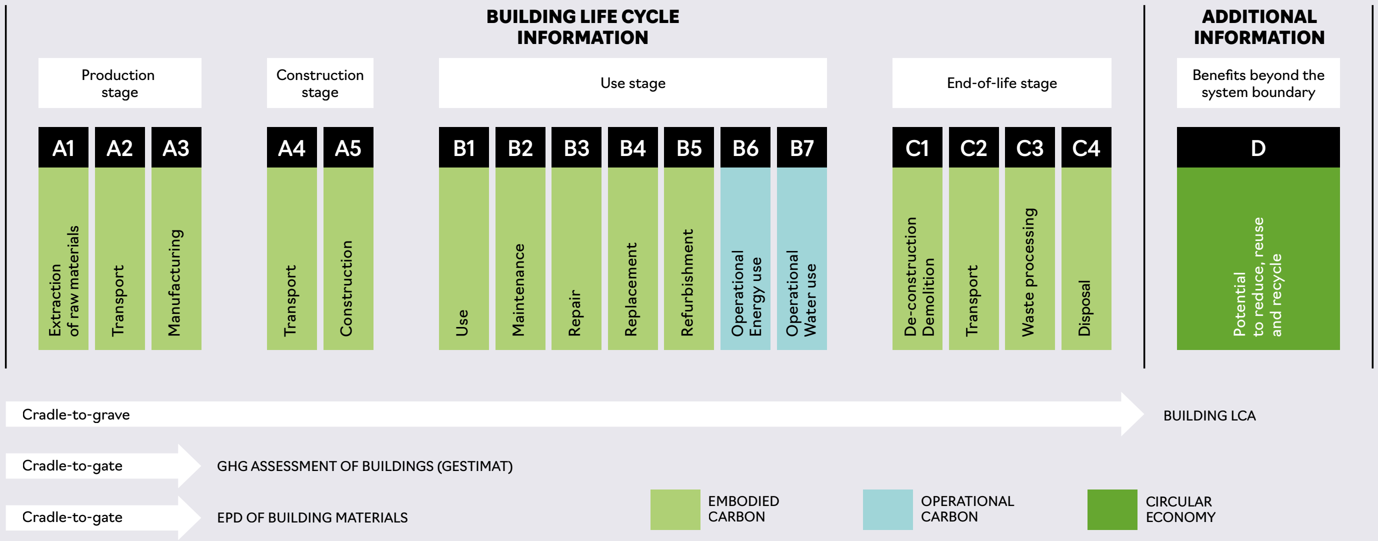
	Type of methodology	Description	Example of tools
	LCA	• Models LCAs based on products or services from all sectors of activity • Assesses one or more environmental impacts, such as global warming, acidification, eutrophication, ozone layer depletion, etc. • Carried out by LCA specialists and verified by a third party • Takes different life cycle stages into account	SimaPro Open LCA GaBi [...]
	Building LCA	• Specifically studies the building • Assesses one or more environmental impacts such as climate change, acidification, eutrophication, ozone depletion, etc. • Relies on generic assumptions • Carried out by LCA specialists or building professionals	Athena IE4B OneClick LCA TallyLCA eTool [...]
	Assessment of building GHG emissions	• Specifically studies the building • Assesses a single environmental impact, i.e., GHG emissions represented by the global warming indicator • Simplified approach • Easier for professionals to use	GESTIMAT/ GHGMAT* EC3 EPIC [...]
	Environmental product declaration (EPD)	• Presents the results of a material-specific LCA • Assess one or more environmental impacts such as global warming, acidification, eutrophication, ozone depletion, etc. • Can be used as a database for LCAs and simplified tools • Carried out by LCA specialists	Transparency catalog CSA ASTM Environdec [...]

Source: Cecobois, 2023

*GESTIMAT/GHGMAT is a free, transparent Web tool developed specifically for Quebec construction professionals and made available online by the Cecobois team in collaboration with the Quebec government.

As described in the EN 15978 standard, the life cycle stages that can be studied as part of an LCA of a building include the production of materials (A1-A3), transportation and the construction of the building (A4-A5), its use (B1-B7) and its end of life (C1-C4), with the option to consider benefits beyond the life cycle (D). The LCA of a material generally covers the production phase (A1 to A3), also known as cradle-to-gate, while the LCA of a building may include the entire life cycle (A1 to C4) or cradle-tograve, as well as potential end-of-life benefits (D).

Building's life cycle stages



Source: Graphic adapted from EN15978

GESTIMAT Version 2.0
Vers une construction à faible empreinte carbone

GESTIMAT / GHGMAT: A tool for assessing GHG emissions

The GESTIMAT/GHGMAT tool was developed with the aim of democratizing GHG assessments for buildings. This tool makes it possible to estimate and compare the GHG emissions from the manufacture of structural and envelope materials for several building scenarios. GESTIMAT/GHGMAT can be used to quantify the potential reduction associated with optimization and choice of materials. The tool uses GHG emissions data that are transparent and representative of Quebec and Ontario.

The tool can also be used from the earliest stages of a project to help guide design choices. Even if little quantified information is known at the preliminary-design stage, it is now possible to easily carry out a GHG assessment for several types of buildings. With only a building's dimensions, number of floors and type of structure, the software quickly calculates its GHG emissions. This GHG assessment at the start of the project makes it possible to compare various scenarios and in order to support the decision-making process.

Once the project is completed and the quantity of materials is known, GESTIMAT/GHGMAT allows users to conduct a more precise GHG assessment by refining the data input to obtain a true comparative analysis of the equivalent tonnes of CO_2 saved per building.

Main differences between the two types of entry in GESTIMAT/GHGMAT: "typical buildings" and "detailed input form"

Design stage	Level of known data for the project	TYPE OF ENTRY IN GESTIMAT/GHGMAT
Preliminary-design stage	**Preliminary (basic data)** The general dimensions of the building are known.	**Typical buildings** With just a few pieces of information about the project, "typical buildings" can be used to calculate the potential reduction of GHG emissions in different scenarios.
Completed project	**Detailed** The quantities of materials are known and can be supplied by the manufacturer.	**Detailed input forms** The actual material quantities included in the completed building can be entered to obtain a more accurate assessment.

Source: Cecobois, 2023

Looking at Building Materials:

Environmental Product Declarations

LEnvironmental product declarations (EPDs) outline the environmental impacts of a material from an LCA carried out by a professional and verified by a third party.[14] The presentation of environmental impact results is similar to a nutrition facts label for food. EPDs for construction materials must comply with the more general ISO 14025 standard and ISO 21930, which is specific to the construction sector. Also, for each product category, the development of the EPD must follow a set of guidelines called the product category rules (PCR).

For the producer or manufacturer, the EPD is used to better understand and publicly disclose the environmental impacts of its products, as well as to potentially reduce these impacts. EPDs are available on the website of the program operator overseeing the publication of the EPD. All North American EPDs are also listed in the Transparency Catalog.[15] The following graphic shows an example of the results found in an EPD, and more specifically, the GHG emitted during the production phase, i.e., from resource extraction to manufacturing.[16]

Extract from the environmental impact results in an EPD published in 2023 for X-Lam™ from Nordic Structures

Environmental product declaration (EPD)

NORDIC X-LAM™

NORDIC STRUCTURES

Impact category	Unit	Total	Resource Extraction	Resource Transportation	Product Manufacturing
			A1	A2	A3
Global Warming	$kgCO_2e$	69.96	37.41	25.68	6.88
Ozone depletion	kgCFC-11e	1.28E-06	4.36E-07	4.52E-08	8.03E-07
Acidification	$kgSO_2e$	0.60	0.37	0.14	0.08
Eutrophication	kgNe	0.05	0.03	0.01	0.01
Smog	kgO_3e	18.45	11.84	4.09	2.52

Source: Environmental product declaration. Nordic X-Lam (10 novembre 2023)

14. Environmental product declarations services. FPInnovations. web.fpinnovations.ca/environmental-product-declarations-services/

15. Sustainable Minds. Transparency Catalog. transparencycatalog.com/

16. Environmental product declaration. Nordic X-Lam. November 10, 2023. https://www.nordic.ca/en/documentation/technical-documents#

Thanks to the growing number of studies and data on buildings, it is already possible to set targets for reducing the embodied carbon content of buildings.

The number of EPDs published in the construction sector has risen sharply in recent years.[17] This democratization is driven by a variety of reasons: a concern for transparency, manufacturers' desire for credibility, a vision of sustainable building, market prerogatives to obtain credits for voluntary certifications such as LEED v4.1, and so on. This has given the industry access to more data on building materials. These data are increasingly used as a reference for building LCAs in certain LCA software or GHG emissions assessment tools.

EPDs are used to better understand the environmental impact of a construction product. However, they are difficult to compare because of the different calculation assumptions or product category rules (PCR) used. As a result, different materials, such as a steel vs. wood beams, cannot be compared based on their EPD. Therefore, it is preferable to carry out an LCA or GHG assessment comparing two project scenarios that use these materials, rather than directly comparing the values from the EPDs.

It is relevant to note that in France, manufacturers must publish an environmental declaration if they wish to voluntarily declare an environmental aspect of their product.[18] This ensures the validity of the manufacturer's claims, since EPDs are verified by a third party. These data are reported in *fiches de déclaration environnementale et sanitaire* (FDES) [environmental and health declaration sheets][19] in France, which require an LCA to be carried out over the product's entire life cycle.

Thanks to the growing number of studies and data on buildings, it is already possible to set and measure the achievement of targets for reducing the embodied carbon content of buildings. Some European countries, such as France, Finland, the Netherlands and Norway,[20] have introduced regulations requiring LCAs to be carried out at the front end of projects in order to encourage builders to choose materials that reduce the carbon footprint of buildings.

HEADQUARTERS OF THE CENTRE DE FORMATION PROFESSIONNELLE DU LOCAL 144, THE FIRST INDUSTRIAL LEED V4 PLATINUM BUILDING IN CANADA

17. Anderson, Jane. 2024. "New Embodied Carbon Toolkit for Architects." ConstructionLCA, January 10, 2024. constructionlca.co.uk/

18. Ministère de la Transition écologique. Déclaration environnementale de certains produits de construction et équipements destinés au bâtiment. [Environmental building and construction equipment product declaration] [French only]. (2020). France ecologie.gouv.fr/declaration-environnementale-certains-produitsconstruction-et-equipements-destines-au-batiment

19. Inies.fr/quest-ce-quune-fdes/

20. OneClick LCA (2022) Construction Carbon Regulations in Europe, Review and best practices.

Reducing embodied carbon in the multi-residential sector

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A study conducted in 2023 by Cecobois, in partnership with L2C Experts-Conseils and funded by Natural Resources Canada, examined the average carbon footprint of the structure of several 5- to 6-storey multi-residential buildings. The results highlight the potential benefits of using wood for this type of construction.

A total of 19 mid-rise multi-residential buildings with different structural systems were studied by L2C Experts-Conseils engineers. This study established a list of the structural materials used in each building. In addition to superstructure materials, the materials making up the structure of the exterior walls, interior walls along the corridors and inter-dwelling walls, whether structural or non-structural, were included in the study. This was done to ensure a proper comparison with light-frame constructions, where these walls are structural. Once this list was created, the GHG emissions caused while manufacturing materials of each of the 19 buildings were assessed using the GESTIMAT/GHGMAT tool.

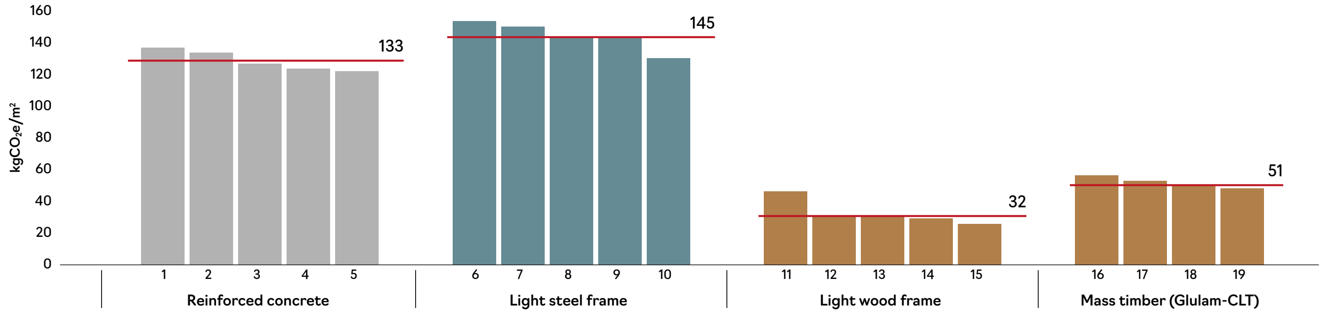
Despite the diverse sizes of the buildings studied, the results indicate that the carbon footprint associated with structural materials is relatively consistent for buildings with the same type of structural system when broken down by square meter of total floor area (m^2) of surface area.

Furthermore, the results of this study revealed that structural wood systems help reduce the carbon footprint of a structure by at least 60%, equivalent to 78 to 113 $kgCO_2e/m^2$ of surface area. The average carbon footprint found for the reinforced concrete buildings assessed was 133 $kgCO_2e/m^2$ of surface area, while that of buildings with a light steel frame structure was 145 $kgCO_2e/m^2$ of surface area. In comparison, the study revealed that buildings with a wood structure have a much lower carbon footprint of 32 $kgCO_2e/m^2$ for light-frame wood buildings and 51 $kgCO_2e/m^2$ of surface area for mass timber buildings.

According to data gathered in another study done by FPInnovations in 2022 on market share in Canada, 88% of 1–4-storey multi-family buildings have a wood structure, compared with 33% of 5–6-storey multi-family buildings. The use of wood in multi-family construction is said to have increased over the past five years. Wood market shares in 5–6-storey multi-residential construction in Quebec have increased by 17% last year. Let's not forget that the Quebec Construction Code has authorized the use of wood since 2015 for this type of construction. To date, Quebec performs better than some other provinces in this sector, but lags behind British Columbia, which stands out with an 80% market share for wood.

According to recent data published by the Association des professionnels de la construction et de l'habitation du Québec (APCHQ), Quebec has a housing deficit of 100,000 units. Considering the current possibilities for constructing wood buildings of 1 to 6 storeys, and soon, up to 12 storeys with the expected adoption of the next construction code, the results of Cecobois' study illustrate the potential for reducing the carbon footprint of these future buildings by using wood.

GHG emissions per total floor area (m^2) of all buildings analyzed in the production phase (A1-A3)
Average emissions ($kgCO_2e/m^2$) for each structural system is represented by a red line



Source : Study on the Average Carbon Footprint of Five- and Six-Storey Multi-Residential Building Structures, Cecobois

What about European policies?

CELIA MAILFERT

CARBON, ECO-MATERIALS AND CIRCULAR
ECONOMY MANAGER, STUDIO CARBONE

AMANDINE CADRO, ARCHITECT AND ENGINEER IN FRANCE

CARBON NEUTRALITY ANALYST FOR NEW AND
EXISTING BUILDINGS, STUDIO CARBONE

MARIKA FRENETTE, ARCHITECT AND URBAN PLANNER IN FRANCE

PRESIDENT AND FOUNDER, STUDIO CARBONE AND WIGNAM®

Making Europe the world's first climate-neutral continent is more than just a catchphrase. The European Green Deal was announced by President of the European Commission Ursula Von Der Leyen in December 2019 and sets out the target of achieving **climate neutrality** in Europe by 2050. This political commitment is now bolstered by the European Climate Law, which was written into law in June 2021 and establishes the so-called "fit for 55" objective, i.e., to reduce greenhouse gas emissions by at least 55% by 2030, using 1990 levels as a baseline. The adoption of this package of legislative proposals is also a concrete expression of the European Union's ambition.

Thanks to the Energy Performance of Buildings Directive (EPBD), which has been in effect since 2002, European countries have a common understanding of the issues at stake and already have strong energy regulations that are constantly being reinforced. However, once energy efficiency has been achieved, embodied carbon will be the primary concern, as it accounts for up to 75% of a building's carbon impact.

In light of this information, according to Xavier Le Den, Director of strategic sustainability consulting at Ramboll, Europe would like to take advantage of the forthcoming update of the EPBD to broaden the thinking on embodied carbon, drawing on the experience of the pioneer states and their desire the request, for new buildings, the evaluation of embodied carbon due to materials manufacturing and construction process.

Definition

Climate neutrality: The balance between a region's greenhouse gas emissions and its capacity to absorb them. The strategy for achieving this balance involves reducing emissions considerably and finding ways to sequester the remaining, unavoidable emissions.

XAVIER LE DEN
RAMBOLL

EUROPE WOULD LIKE TO TAKE ADVANTAGE OF THE FORTHCOMING UPDATE OF THE EPBD TO BROADEN THE THINKING ON EMBODIED CARBON, DRAWING ON THE EXPERIENCE OF THE PIONEER STATES AND THEIR DESIRE THE REQUEST, FOR NEW BUILDINGS, THE EVALUATION OF EMBODIED CARBON DUE TO MATERIALS MANUFACTURING AND CONSTRUCTION PROCESS.

To date, because there is no directive on embodied carbon, there are significant disparities between the various states. While Belgium is learning about the challenges of embodied carbon and proposing voluntary measures via the TOTEM tool, Sweden, which has always been a progressive country, is imposing the Klimatdeklaration to quantify embodied carbon for the construction of new buildings. According to Carl Bäckstrand, Vice-President and Director of White International, the Swedish government just announced that, since the decarbonization targets for the transportation sector have not been met, efforts in the building sector will be stepped up, and the introduction of regulatory thresholds for embodied carbon will be carried forward to 2025.

France is the most advanced country, thanks to the Environmental Regulation 2020 (RE2020), which came into effect in 2022 and sets new thresholds. At the same time, other laws have been enshrined in France to support low-carbon construction, such as the Anti-Waste for a Circular Economy Law (AGEC) in 2020 and the Climate and Resilience Law in 2021, notably to encourage the use of reused, reclaimed and bio-based materials. Nevertheless, depending on the project, fire regulations (the equivalent of the National Fire Code of Canada) may become an issue for the use of these materials.

What's more, these materials' sensitivity to water can also be seen as a hindrance. However, this problem can easily be countered with appropriate design and hygrothermal transfer studies to ensure the longevity of walls. Against this regulatory backdrop, Fibois[21] is working in the regions to support contractors, rolling out and facilitating the use of these materials. This additional commitment to bio-based products, which provide an effective solution to environmental, economic and social challenges, reflects a real desire to achieve carbon neutrality.

21. Fibois France is the umbrella organization for the 12 regional forestry and wood industry associations.

What are Canada's strategies for decarbonizing buildings?

The Canadian federal government is taking action in the fight against climate change, having updated the Greening Government Strategy in 2020. This commitment applies to all key government departments and agencies to achieve net-zero emissions by 2050, with a real commitment to accelerating the reduction of carbon in various sectors, including the buildings sector.

For new buildings and major renovations, the government will prioritize low-carbon strategies and climate resilience.[22] Thanks to the National Energy Code of Canada for Buildings, there is a desire to expand on the work done in past years on the energy efficiency of buildings and operational carbon, while simultaneously starting to take action on embodied carbon. One of the objectives is to carry out LCAs of major federal projects by 2025 to achieve a 30% reduction in their impact.

To support this federal strategy, the National Research Council's (NRC) decided to implement the Platform for Large-Scale Decarbonization of the Construction Sector at Scale. The aim of this project is to develop new language for the 2025 and 2030 National Model Codes that will make it possible to regulate operational and embodied carbon, respectively. Mehdi Ghobadi, Research Officer and LCA Theme Lead at the NRC, said that a literature review is currently under way. At this stage, the literature shows that there is still work to be done to complete databases, standardize tools and integrate electromechanical systems into the scope of the study. Change management and deploying professional skills in energy and carbon simulation, along with a knowledge of building science, will be the challenges of the future if the building sector is to achieve its objectives.

On this subject, Mr. Ghobadi is cautious about the notion of "net-zero emissions," pointing out that because of embodied carbon, a true net-zero emissions building is one that is never built. He noted that codes only define the minimum level to be reached, and that it is possible, and even recommended, to go further. Like in Europe, some Canadian provinces and cities have decided to take the lead on the issue of embodied carbon after realizing that operational carbon alone would not be enough to meet the sector's GHG reduction targets.

A TRUE NET-ZERO EMISSIONS BUILDING IS ONE THAT IS NEVER BUILT.

MEHDI GHOBADHI
NATIONAL RESEARCH COUNCIL OF CANADA (NRC)

22. TREASURY BOARD OF CANADA SECRETARIAT. 2023. "Greening Government Strategy: A Government of Canada Directive." Government of Canada. canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html

For example, British Columbia's CleanBC Roadmap to 2030 includes pathways to reduce embodied carbon. A low-carbon materials program as well as quantification methods are currently being developed, with the aim of setting targets for the reduction of embodied carbon in public buildings by 2030 and identifying the means to achieve them. In 2023, at the International Mass Timber Conference, British Columbia's Minister of State for Trade, Jagrup Brar, issued a press release stating that "Mass-timber construction plays an important role in advancing CleanBC climate goals by providing a smaller carbon footprint throughout the building's life cycle, compared to using concrete[23]".

The City of Toronto implemented its TransformTO Net Zero Strategy to achieve net zero by 2040. To achieve this, it has incorporated embodied carbon requirements into the *Toronto Green Standard* (TGS), which is the city's sustainable design and performance requirements that building developments must meet through the planning approval process. Based on the TGS V4, city-owned and privately-owned buildings are subject to different embodied carbon requirements. Privately-owned buildings must undergo an LCA and report their emissions. City-owned buildings are also required to carry out an LCA and demonstrate compliance with a maximum emissions threshold. By 2025, privately-owned buildings will also have to comply with thresholds, which have been set according to various building types. Materials production (shell and structural materials) and building construction stages (A1 to A5) are presently covered by the TGS V4 standard.

Lastly, the City of Vancouver recently established itself as an environmental leader by including regulatory requirements on embodied carbon in the *Vancouver Building By-law* (VBBL), making it the first by-law in North America to address embodied carbon emissions from buildings. The first version of the Embodied Carbon Guidelines[24] was published in October 2023. It contains guidance for LCA professionals on how to comply with the requirements and help achieve the goal of reducing embodied carbon by 40% by 2030, a target set by British Columbia's Climate Emergency Action Plan. According to Patrick Enright, Senior Green Building Engineer, City of Vancouver, this policy comes with knowledge sharing, education, raising industry awareness and creating connections between developers, designers, materials suppliers and policymakers. For now, this plan only applies to buildings over 600m^2 or 3 storeys,[25] and it includes a requirement to calculate the carbon footprint of the structure and envelope over the entire life cycle of the building.[26] To comply with the requirements, the building must adhere to one of the two proposed reduction pathways: either by reducing carbon in relation to a reference building and demonstrating that there is a reduction in emissions or by meeting an absolute embodied carbon intensity value set at 800 $kgCO_2/m^2$ (i.e., double the average value obtained in their benchmark study of 400 $kgCO_2/m^2$).[27]

"THE BIGGEST OPPORTUNITY FOR DECARBONIZATION CAN BE FOUND IN CARBON-STORING MATERIALS, SUCH AS BIOMATERIALS (E.G., WOOD-FIBRE INSULATION, HEMPCRETE, STRAW, WOOD) AND EVEN IN LOW-CARBON CONCRETE, WHICH SOME OF THE MAJOR MANUFACTURERS ARE BEGINNING TO OFFER AS A SUPERIOR-QUALITY PRODUCT."

PATRICK ENRIGHT
SENIOR GREEN BUILDING ENGINEER, CITY OF VANCOUVER

23. CLF British Columbia. 2023. "The City of Vancouver's Embodied Carbon Guidelines." The B.C. Green Event Calendar, November 29, 2023. bcgreeneventcalendar.ca/city-vancouvers-embodied-carbon-guidelines

24. City of Vancouver's Embodied Carbon Guidelines

25. British Columbia Building Code: Part 3: Buildings

26. A1 to C4: materials manufacturing, construction, operation and deconstruction

27. CLF British Columbia. 2023. "The City of Vancouver's Embodied Carbon Guidelines." The B.C. Green Event Calendar, November 29, 2023. bcgreeneventcalendar.ca/city-vancouvers-embodied-carbon-guidelines

A growing role for wood in construction

GABRIELLE PICHETTE, ENG., M. SC.

TECHNICAL ADVISOR, SUSTAINABLE CONSTRUCTION, CECOBOIS

CAROLINE FRENETTE, ENG. PH. D.

SENIOR MANAGER, SUSTAINABLE CONSTRUCTION AND TRAINING, CECOBOIS

Wood is a renewable, local material with a low carbon footprint, making it a key ally in the fight against climate change. In addition to its environmental performance, wood facilitates prefabrication, simplifies foundation and finishing elements and provides better thermal insulation.

How do trees sequester carbon?

Wood is one of the few building materials capable of storing carbon over its entire lifespan. Through the process of photosynthesis, trees absorb carbon dioxide (CO_2) from the atmosphere and transform it into oxygen (O_2). It then uses the carbon (C) in the CO_2 to form its material (wood), enabling it to grow. In general, it is estimated that 1 m^3 of wood sequesters just under 1 tonne of CO_2. Once mature, the tree grows at a slower rate and stores less carbon. After 75 to 120 years of life, trees will eventually die and decompose naturally, aided by fungi and/or insects, or sooner if burned in a forest fire. In this way, much of the carbon accumulated during its life will be returned to the atmosphere in the form of CO_2, thereby completing the forest carbon cycle. The harvested tree is replaced by a younger one, thus starting a new cycle of carbon sequestration cycle. By using wood as a building material, we delay the moment when this carbon is released or re-emitted into the atmosphere. Therefore, it is possible to extend forest carbon sequestration beyond the life of the tree by using it as a building material.

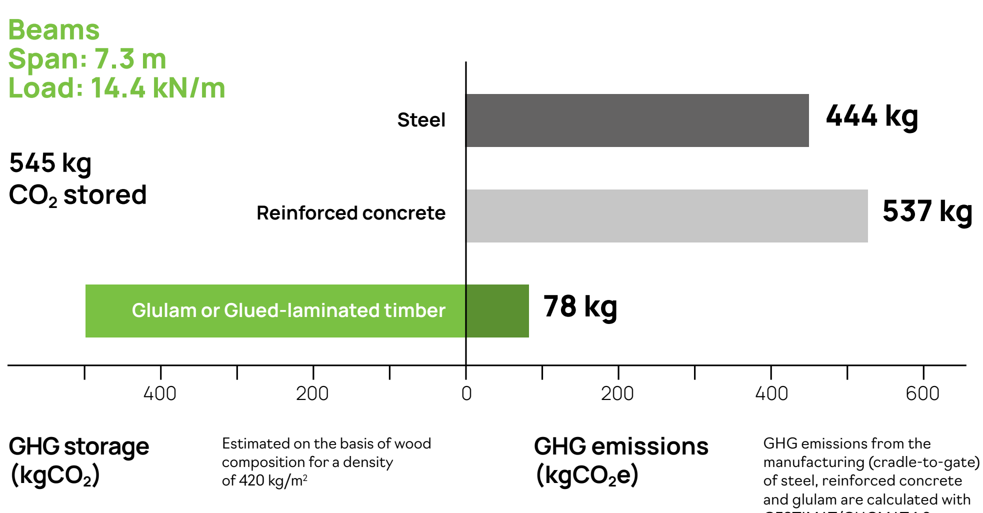
Why use wood in construction?

Materials used in the construction sector, such as steel and concrete, generate a significant amount of GHG emissions over their entire lifespan due to the extraction of raw materials, the manufacturing stage, their use and their end-of-life sequence. On the other hand, in addition to having a low carbon footprint, wood generates only a small amount of GHG emissions linked to the harvesting and manufacturing stage. Not only is it capable of storing carbon, but it does so for the entire life of the product.

CAMP-DE-TOUAGE SERVICE CENTER

To provide a valid basis for comparison between the three materials (steel, concrete and wood), Cecobois used the GESTIMAT/GHGMAT tool to compare a single-support beam with a standard load case (14.4 kN/m) and a standard span (7.3 m). For a beam carrying the same load and span, glulam emits just 78 kgCO_2e versus reinforced concrete and steel with 444 and 537 kgCO_2e respectively, a reduction of over 80%. What's more, this same wood beam will store 545 kgCO_2 over its lifetime.

GHG emissions results for the manufacture of a beam, considering cross-laminated timber, reinforced concrete and steel scenarios.



Source: Cecobois

The advantages of building with wood

1 FACILITATES PREFABRICATION

Prefabrication is a construction practice that enables several factory-built building components to be assembled directly on site. This practice offers many advantages, such as improved cost and time management, a safe working environment, higher productivity, higher quality, faster construction and reduced waste generation. Wood is a material that lends itself well to prefabrication because the factory allows the optimisation of cutting patterns. Moreover, material losses generated by cutting are more easily sorted and reintegrated into the production chain than if they had been generated on the construction site.

2 SIMPLIFIES FOUNDATIONS AND FINISHING ELEMENTS

Wood building structures are considerably lighter than structures made of steel or concrete, and they can help make foundations less complex. This can be particularly advantageous in projects on sites with low load-bearing capacity or those requiring the addition of another storey to an existing building.

Because of their natural fire resistance, Glulam and CLT structures are often left exposed, requiring fewer finishing elements than other structural systems. These structural systems make the building seem more welcoming, providing added value.

3 PROVIDES SUPERIOR THERMAL INSULATION

In addition to the importance of embodied carbon, the energy efficiency of buildings remains a key consideration in the 2030 PGE. The plan urges the reduction of energy consumption in buildings. That said, using less energy requires better insulation. As wood's thermal resistance is 500 times greater than that of steel and seven times greater than that of concrete, its use in structural products reduces thermal bridges and makes it easier to install effective thermal insulation. Reducing the transfer of heat through building walls reduces energy consumption for heating and ventilation while increasing user comfort.

This natural property of wood is also featured in the development of various bio-sourced insulating panels.

INTERIOR VIEW OF THE CHIBOUGAMAU-CHAPAIS AIR TERMINAL

Carbon sequestration and substitution: Two benefits of wood in the movement toward carbon neutrality

VALÉRIE LEVÉE
SCIENCE AND ARCHITECTURE JOURNALIST

Building with wood offers two benefits when it comes to decarbonizing buildings: wood stores forest carbon and reduces the use of materials with a high carbon footprint.

Through photosynthesis, trees capture CO_2 from the air and use the sun's energy to transform it into cellulose and lignin, the main components of wood. As long as trees are alive and growing, they sequester carbon in their wood and keep it out of the atmosphere. When they die, fallen wood decomposes and emits CO_2. As a result, they return a large part of the CO_2 stored during their growth to the atmosphere. This is the forest carbon cycle. This is also known as bio-sourced or biogenic carbon, as opposed to fossil carbon from fossil fuels.

Prolonging sequestration

Harvesting trees to turn them into furniture, beams, cladding or other wood products allows CO_2 to continue to be stored inside the wood and kept out of the atmosphere, while a new generation of trees takes over the forest carbon cycle. Trees sequester CO_2 from the atmosphere and store it in its plant mass, and then this plant mass becomes part of wood products. During this time, this CO_2 stays contained. This dynamic is of even more interest if the forest carbon is transferred to long-lasting wood products, explains Évelyne Thiffault, Professor, Département des sciences du bois et de la forêt [Department of wood and forest sciences], Université Laval. Therefore, it makes perfect sense to use wood in the construction sector.

It is true that trees would also continue to sequester carbon in their wood if they were not harvested. However as they age, they photosynthesize less than they did during their growth stage, and their ability to capture CO_2 from the air diminishes.

"SOCIETY WILL CONTINUE TO NEED MATERIALS AND ENERGY, BUT THE MORE WE CAN MEET THESE NEEDS WITH BIO-BASED, NON-FOSSIL CARBON, THE BETTER IT IS FOR THE CARBON BALANCE, PROVIDED THAT THE FOREST IS WELL MANAGED TO ENSURE TREE REGENERATION."

ÉVELYNE THIFFAULT
UNIVERSITÉ LAVAL

Despite forest harvesting, the large carbon reservoir in the soil will stay contained as long as the forest survives. Hence the interest in harvesting to transfer stored carbon to buildings. This will pass the work of absorbing CO_2 through photosynthesis onto young trees, which will sequester new carbon stocks.

Reduction through substitution

According to the sixth report from the Intergovernmental Panel on Climate Change (IPCC), wood and earth are the building materials with the lowest carbon footprint. Turning wood into wood construction materials requires less energy than turning iron ore into steel beams or making concrete. Substituting a high-carbon material with wood is one way of reducing a building's carbon footprint.

Reusing wood materials beyond their linear lifecycles and integrating them into a circular economy is a major challenge due to the many issues that arise: safety, environmental criteria, lack of training and support, deconstruction versus demolition costs and the lack of collaboration between the various players. However, the circularity of wood materials offers the potential for significant reductions in GHG emissions and reduced consumption of water, energy and raw materials. Extending the lifecycle is typically the top priority. If we can do more with the same wood, we can increase our substitution potential tenfold. This leaves more wood available to use instead of concrete or steel if we extend the lifespan or reuse components, explains Annie Levasseur, Research Chair in Measuring the Impact of Human Activities on Climate Change, Director, Centre d'études et de recherches intersectorielles en économie circulaire (CERIEC), and Professor, Département de génie de la construction [Department of construction engineering], ÉTS. In summary, by extending the life of wood through reuse, the potential for substitution is ten times greater.

"EXTENDING THE LIFECYCLE IS TYPICALLY THE TOP PRIORITY. IF WE CAN DO MORE WITH THE SAME WOOD, WE CAN INCREASE OUR SUBSTITUTION POTENTIAL TENFOLD. THIS LEAVES MORE WOOD AVAILABLE TO USE INSTEAD OF CONCRETE OR STEEL IF WE EXTEND THE LIFESPAN OR REUSE COMPONENTS."

ANNIE LEVASSEUR
ETS

From forest carbon to wood products

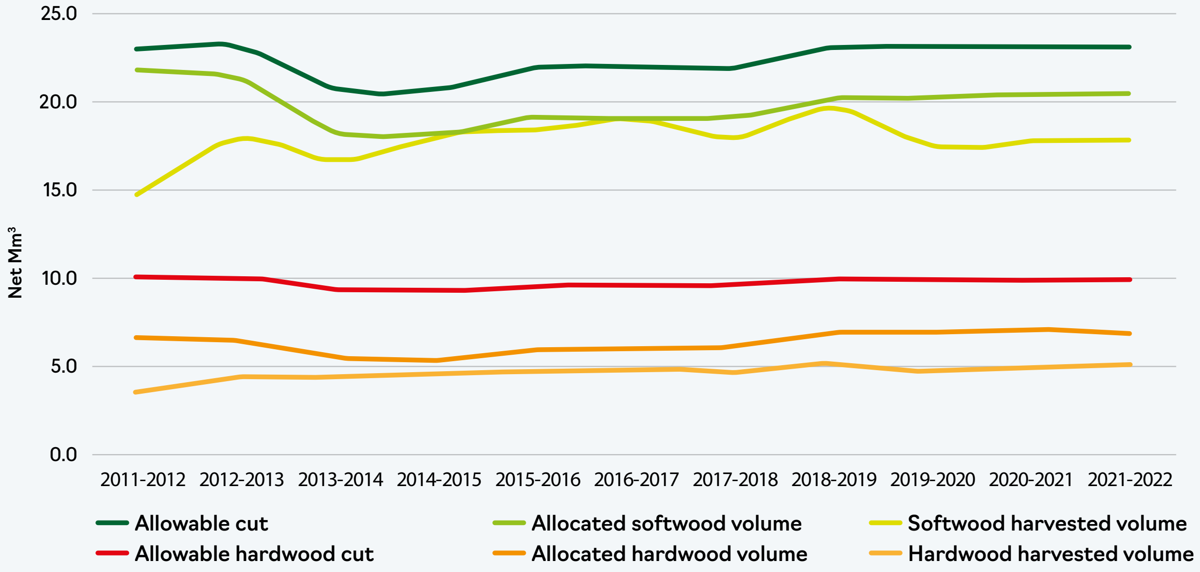
Wood is a renewable and sustainable material, provided that we do not harvest it faster than the forest grows. However, the forest could provide more without jeopardizing its sustainability.

In 2005, the position of Forestier en chef [Chief forester] was created and assigned a mission to determine the allowable cut, i.e., the maximum amount of wood that can be harvested from public forests under management. To make this calculation, forest growth is modelled over 150 years with different management scenarios. The allowable cut corresponds to the management strategy that maximizes productivity and harvesting while ensuring forest growth based on relevant sustainable forest management objectives.

In order to achieve carbon neutrality, it would also be ideal to optimize the sequestration of carbon by forests. The more carbon the forest stores in its trees, the more forest carbon will be available for transfer to wood products.

For each management unit, we can estimate carbon stocks and flows. We can predict whether they will increase or decrease depending on the management strategy, says Jean Girard, Directeur du calcul et des analyses au Bureau du Forestier en chef [Director of calculation and analysis at the Office of the chief forester]. Under Quebec's Sustainable Forest Management Strategy, forest or biogenic carbon is to be included in the calculation of allowable cut. This is the next generation of calculations. Among the various management scenarios, we want one that is more beneficial in terms of carbon, with the same allowable cut, says Jean Girard.

Allowable cut, net allocated volumes and net harvested volumes, by group of species, public forests[28]



28. Ministère des Ressources naturelles et des Forêts, Direction de la gestion de l'approvisionnement en bois, Bureau de mise en marché des bois and Direction de la coordination opérationnelle

Silviculture can also be optimized to improve carbon sequestration by trees and, by the same token, forest productivity. The most common harvesting strategy is one that protects regeneration and the soil. In other words, very young trees are protected during harvesting, so they go on to become the future forest. We have an extensive management system based largely on natural regeneration, wherein we make sure to preserve the naturalness of the forest without necessarily turning it into a forest whose main purpose is timber production. The calculation of the allowable cut is not aimed at intense production, but rather at forest management that takes into account a wide range of considerations, notes Jean Girard.

"FOR EACH MANAGEMENT UNIT, WE CAN ESTIMATE CARBON STOCKS AND FLOWS. WE CAN PREDICT WHETHER THEY WILL INCREASE OR DECREASE DEPENDING ON THE MANAGEMENT STRATEGY."

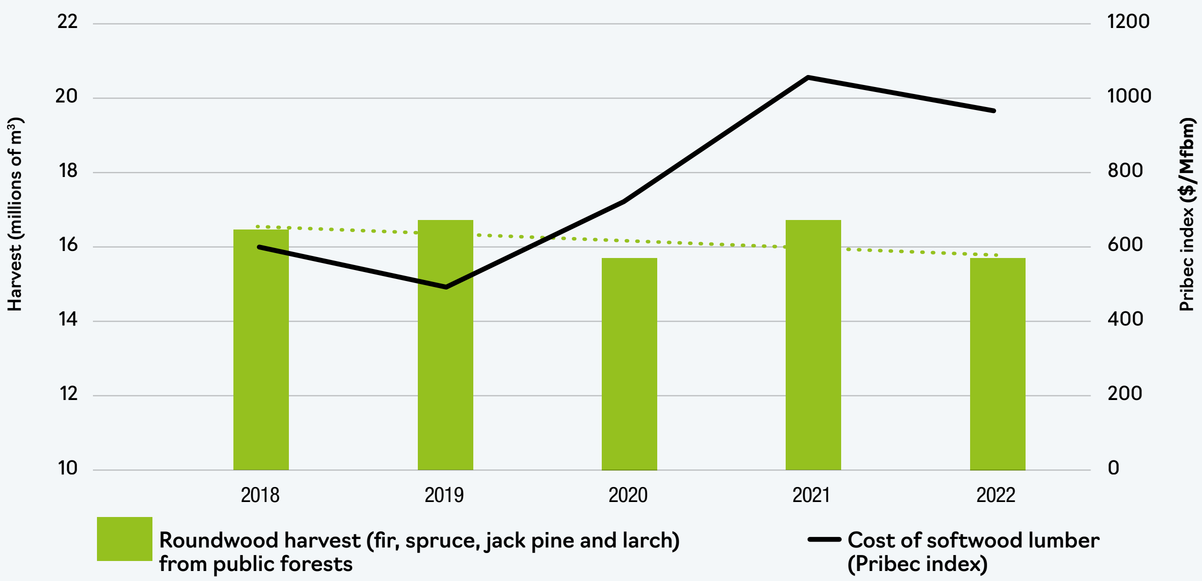
JEAN GIRARD
OFFICE OF THE CHIEF FORESTER

Évelyne Thiffault, Professor, Département des sciences du bois et de la forêt [Department of wood and forest sciences], Université Laval, shares the same opinion: research shows that if we monitor regeneration more closely to ensure that the forest regeneration is optimal, we can make gains in terms of carbon sequestration.

Over the past five years, the harvest of fir, spruce, jack pine and larch from public forests has remained virtually unchanged, despite a historic upturn in prices. In short, even if demand for wood soars (lumber or increased use of wood in buildings), this has no impact on forest harvesting. The Chief forester's calculation is what determines what the forest can yield, regardless of the market.

Even with current silviculture practices, allowable cuts have not been fully taken advantage of, as some hardwood species are not harvested for lack of use. However, they can be used in the production of wood composite panels that have the potential to replace other construction materials. These sectors would benefit from using these species, says Jean Girard.

Evolution of the cost of softwood lumber versus the level of harvest from public forests



Sources: MRNF (forestry record) and CIFQ (Pribec)

Definition

Mfbm: is a unit of volume used for sawn timber. Mfbm stands for thousand board feet.

Decarbonizing with professionals

AMANDINE CADRO, ARCHITECTE ET ING.
CARBONNEUTRALITY ANALYST, NEW AND EXISTING BUILDINGS STUDIO CARBONE, IN FRANCE

CELIA MAILFERT
CARBON DIVISION MANAGER, ECO-MATERIALS AND CIRCULAR ECONOMY STUDIO CARBONE

Professionals have realized that the contribution of embodied carbon in the building sector emissions is significant. The gradual introduction of voluntary approaches and regulations in this area is leading to necessary changes in practices. A number of building professionals were interviewed in Europe and Canada to find out how the spotlight on embodied carbon affects their work.

CARL BÄCKSTRAND
WHITE INTERNATIONAL

"WITH NEW BUSINESS MODELS, NEW SUPPLY CHAINS AND NEW GUARANTEES, IT IS NOT JUST ABOUT A NEW MATERIAL."

Swedish Architect Carl Bäckstrand, Deputy CEO at White Arkitekter, points out that the entry into force in 2022 of "KlimateDeklaration" (Sweden's climate declaration)[29] making it mandatory to measure the amount of embodied carbon in buildings over 100 m^2 was rather well received by dedicated specialists like those at White. They saw it as an opportunity to put their skills to good use and get used to these approaches before the carbon thresholds were put in place, whereas property developers, who were not as prepared for the changes, were more reticent and feared seeing construction costs rise. The changes were positively received within his firm, which was already well versed in wood construction. The younger generation has embraced the changes, driven by their deep commitment to addressing the climate emergency. Consequently, they are eager to accelerate advancements in this field.

Bäckstrand has noticed demand from clients and investors who are increasingly persuaded of the urgency to integrate these changes into their projects, especially given the requirements of European green taxonomy. This framework mandates that they demonstrate how their investment portfolios actively promote the shift toward a low-carbon, resilient market. He believes that professionals and manufacturers are just starting to implement the changes to be made in the sector. Because woodworking is a tradition in Sweden, Swedes have the expertise to innovate and promote more resource-efficient construction and therefore much more sustainable building structures and methods. The challenges lie more in using the circular economy, which requires the sector to implement further changes with new business models, new supply chains and new guarantees; it is not just about a new material. This will disrupt the current vision of architectural aesthetics, and at White, we are inspired by a new quest for aesthetic within circular design.

29. KlimateDeklaration

In France, architect and urban planner Marika Frenette explains a paradigm shift over the past two years regarding environmental challenges. We have transitioned from an inadequate concept of sustainable development to a more ambitious approach emphasizing resilience, low-tech solutions, frugality and sobriety. The high regulatory standards set surrounding climate, resilience and the circular economy (ZAN[30] and AGEC[31]) have, in hindsight, proven to be an extremely powerful and impressive tool for launching the required shift toward decarbonization. Initially viewed as a limitation, building professionals now regard these standards as a potential catalyst for changes in practices. Following a phase of uncertainty that included doubts about feasibility or objections stemming from the unknown, these new regulations have emerged as an undeniable force for transforming the entire value chain. This includes manufacturers, contractors, architects, engineers, and notably, project owners. In fewer than three years, we have made giant strides that would not have been possible without a bold regulatory policy.

These new regulations have led to several outcomes. Companies that traditionally focused on concrete construction are now venturing into high-rise wood buildings. Manufacturers, previously reliant on fossil-based components, are now pioneering the development of bio- or geo-sourced products. Municipalities are reassessing their urban expansion policies to repurpose abandoned land. Online platforms facilitating the sale of reused materials, backed by insurer guarantees, are beginning to surface. Project owners are now prioritizing biodiversity and user experience while working toward low-carbon buildings.

In my 20 years of environmental work, the past three years in France stand out as the most hopeful, remarks Marika Frenette. It's all about pursuing meaningful growth. Decarbonizing the construction sector hinges on awareness and humility; we should only build when necessary. Building with wood is not the endpoint; it marks the beginning of a fresh mindset aligned with the principles of regenerative development.

MARIKA FRENETTE
WIGWAM® AND STUDIO CARBONE

"BUILDING WITH WOOD IS NOT THE ENDPOINT; IT MARKS THE BEGINNING OFA NEW WAY OF THINKING."

CAROL PHILLIPS
MORIYAMA TESHIMA ARCHITECTS

"WORKING WITH WOOD HAS DEEPENED MY CONNECTION TO MATERIALS LIKE NEVER BEFORE."

In Canada, architect Carol Phillips, from Moriyama Teshima Architects, has always advocated for wood solutions with her clients. As a designer, she has consistently emphasized the significance of materiality in shaping project identities. Yet, she emphasizes that working with wood has deepened her connection to materials like never before. This connection allows her to ground her practice in her roots near the Amazon rainforest. She vividly remembers the day she witnessed a tree being harvested, an experience that instilled in her a visceral understanding of her responsibility to use the material thoughtfully, to trace its origins and to care for the forest. While she acknowledges gradual shifts, such as architecture and engineering schools incorporating low-carbon concepts into their curriculum and the expansion of firms specializing in wood construction, she advocates for a faster pace of change and broader adoption of wood building construction beyond special projects. She insists that genuine transformation in the industry will only occur with comprehensive regulations addressing embodied carbon. Drawing from her recent trip to France, she remarked on the impact of regulations like RE2020[32] on reshaping the social process changing the urban fabric. She observes a trend toward more restrained architecture with increased use of wood in various forms and a reduction in the use of glass, in contrast with the glass towers she sees in Toronto.

30. Zéro Artificialisation Nette.

31. Loi Anti-Gaspillage pour une économie circulaire.

32. Environmental regulations with simultaneous thresholds for operational carbon and embodied carbon.

Low-carbon projects

© EINAR ASLAKSEN

The Plus: A model for industrial ecological design

MARTIN LARUELLE
PUBLIC COMMUNICATIONS STUDENT, CECOBOIS

From the outset, The Plus project placed decarbonization at the heart of its vision.

A green and innovative building

Located in Norway, the building stands out as industrial infrastructure specializing in furniture manufacturing. The driving force behind the innovative use of wood in the construction of The Plus was the pursuit of Building Research Establishment Environmental Assessment Method (BREEAM) certification, a widely recognized method for evaluating the environmental sustainability of buildings. This marked a milestone, as The Plus became the first industrial facility to earn such recognition.

Spanning an impressive 7,000 m^2, The Plus proudly claims the title of the world's cleanest and lowest-carbon street furniture production facility. It was built using locally sourced solid wood, low-carbon concrete and recycled steel. Viktoria Millentrup, Architect at the Bjarke Ingels Group and Project Manager for The Plus, shares the challenges they encountered during construction of The Plus.

She explains that the first obstacle they had to contend with was the absence of BREEAM guidelines for industrial buildings. At that time, there was no precedent for industrial buildings in terms of sustainability. The situation may have evolved since then, but since the team only had BREEAM standards to go on, without any specific guidance on sustainable construction for industrial facilities, they were essentially in uncharted territory. BREEAM was mainly focused on buildings such as schools, hotels and homes, categories typically associated with sustainability certifications. This was the crux of the first challenge.

The distinctive cross-shaped layout of The Plus, after which it is named, delineates four distinct segments corresponding to different factory functions: a warehouse, a stain facility, a woodworking unit and an assembly line. The two-storey building boasts cutting-edge automation technology, significantly reducing the need for manual labour. Standardized building components sourced from manufacturers facilitated a streamlined construction process. Furthermore, the strategic placement of office spaces and exhibition areas at elevated levels provides panoramic views without disrupting the overall structure. The incorporation of wood into the design of The Plus not only enhances its ecological footprint but also adds an aesthetic aspect, making it a distinctive and environmentally responsible landmark.

"IT IS IMPERATIVE THAT THE WOOD USED IN CONSTRUCTION ORIGINATE FROM SUSTAINABLY MANAGED FORESTS WITH REFORESTATION PRACTICES IN ORDER TO MAINTAIN ECOLOGICAL BALANCE. SUSTAINABILITY EXTENDS BEYOND MATERIAL SOURCING; IT ENCOMPASSES THE STRUCTURE'S LIFE CYCLE."

VIKTORIA MILLENTRUP
BJARKE INGELS GROUP

Pioneering decarbonization

The Plus epitomizes an innovative approach to decarbonization, explains Viktoria Millentrup. From the project's inception, the paramount focus was on minimizing its carbon footprint. This commitment was apparent in the exclusive use of electric vehicles on site and electricity sourced from renewable sources, along with a strong preference for local resources.

The cornerstone of our approach is maximizing the use of local resources, whether for construction machinery, labour or materials. This aligns with our choice to use wood, a building material renowned for its ability to store CO_2. However, it is imperative that the wood used in construction originate from sustainably managed forests with reforestation practices in order to maintain ecological balance. Sustainability extends beyond material sourcing; it encompasses the structure's life cycle.

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AERIAL VIEW OF THE PLUS

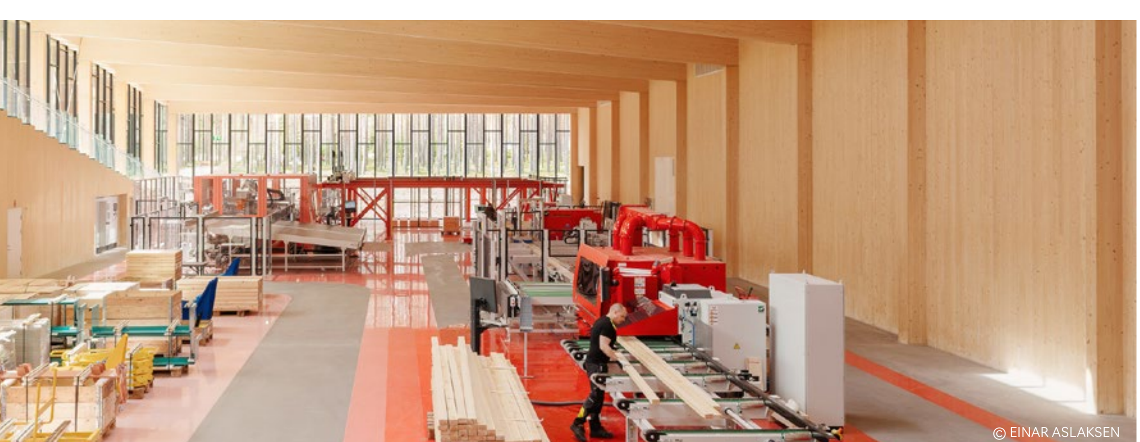
INSIDE THE PLANT LOCATED IN THE PLUS

Our methods prioritize disassembly and reuse to minimize environmental impact. Our passive building is designed in a way that departs from industrial norms and is adaptable for various reuses, such as a museum or a kindergarten, offering unparalleled versatility in the industry.

Lastly, minimizing maintenance was a crucial criterion. It was achieved through a careful selection of the right materials and facades as part of an overall aim to reduce constraints and design considerations while establishing The Plus as an exemplar of ecological innovation.

An environmentally friendly building

The Plus project has embraced innovative construction techniques to mitigate its environmental impact while ensuring long-term sustainability. One of the most remarkable approaches is building from the inside out, an unconventional yet ecologically responsible process. Rather than creating an extensive construction site with materials stored on site, all materials were kept off-site and brought in as needed. This approach minimized tree cutting and preserved the proximity of existing trees. Although it diverged from conventional construction practices, the team remained steadfast in its commitment to reducing the building's environmental impact. Furthermore, opting for burnt wood for the building's exterior finishes ensures nearly 60 years of durability without the need for chemical maintenance products, underscoring a long-term dedication to biodiversity preservation and building maintenance. Ultimately, The Plus embodies a vision of construction in harmony with its environment.



VIEW INSIDE THE PLANT AT THE PLUS, WITH A VIEW OF THE SURROUNDING FOREST

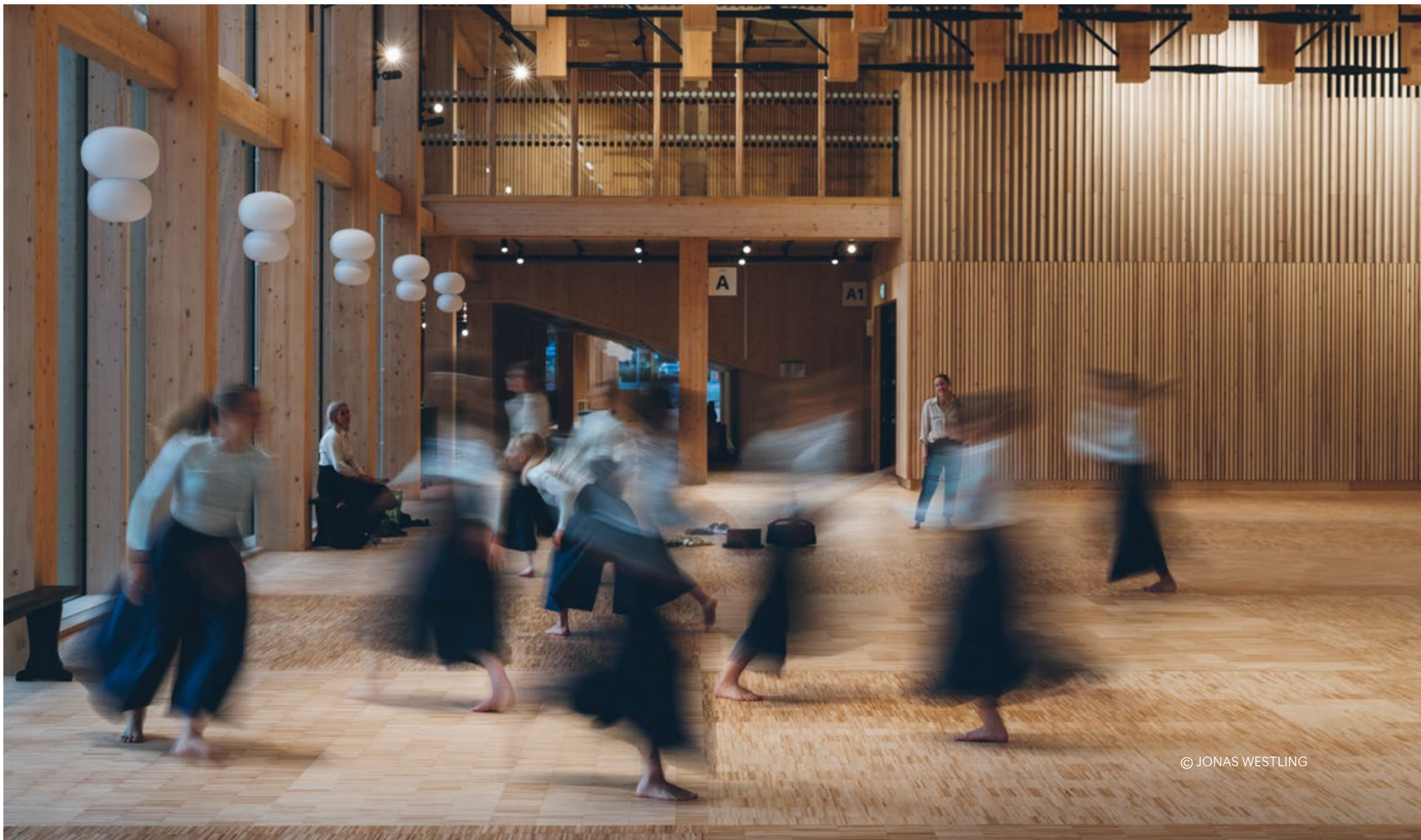
Sara Cultural Center: The sustainable future of solid wood construction

At the outset, the objective was clear: to showcase the use of wood in the construction of the Sara Cultural Centre.

Located in the Swedish town of Skellefteå, the centre is much more than a mere building. The centre opened in 2021 and is home to a cultural hub housing a municipal library, art gallery, museum and six stages dedicated to the performing arts. An adjacent tower, transformed into a hotel, soars 20 stories high and boasts over 200 rooms, three restaurants, a rooftop spa and conference facilities. Built primarily from wood sourced from regional boreal forests, the centre was designed to reduce embodied and operational carbon emissions. In 2022, it garnered significant acclaim from industry peers, earning the prestigious Prix International de l'Architecture Bois.

Because it is deeply ingrained in the Swedish ethos of sustainable development, the town of Skellefteå inspired the designers to use this renewable material to its fullest potential. Silviculture is the art of sustainable forest management that involves planning the planting, maintenance and harvest of trees to meet timber needs while maintaining the ecological balance of the forest ecosystem.

PEOPLE DOING INDOOR ACTIVITIES AT THE SARA CULTURAL CENTRE




THE WOOD HOTEL

WOODEN PERFORMANCE STAGE

"ONE OF THE BIGGEST CHALLENGES OF THE PROJECT WAS TO CONVINCE PEOPLE TO BUILD SOMETHING THAT HAD NEVER BEEN BUILT BEFORE. BY HARNESSING OUR WILL AND AMBITION TO INNOVATE IN WOOD ARCHITECTURE AND SUSTAINABLE CONSTRUCTION, WE HAVE NOW COMPLETED THE PROJECT WITH AN ALL-WOOD STRUCTURE."

ROBERT SCHMITZ
WHITE ARKITEKTER

Robert Schmitz, Principal Architect and Project Manager at White Arkitekter, explains that Skellefteå has a long tradition of wood construction. The town has a wealth of knowledge about wood, both in construction and in the wood-processing industry. Notably, one of the world's foremost manufacturers of cross-laminated timber (CLT) is located just beyond the city centre.

Moreover, Schmitz insists on using certified sustainable wood, ensuring the replacement of each felled tree with two new ones to maintain the forest's balance. While a life cycle assessment (LCA) wasn't conducted pre-construction, operational carbon emissions remain low, averaging around 200 $kgCO_2e/m^2$. Yet, thanks to carbon sequestration, the net balance veers negative, storing more carbon than it emits over a span of 50 years or more.

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SARA CULTURAL CENTRE ALL LIT UP

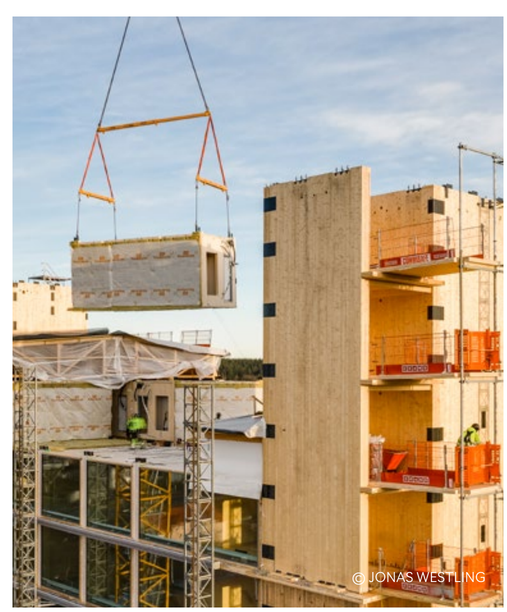
Innovative construction techniques

Standing nearly 80 metres tall, the tower part of this pilot project, now being used as a hotel, is garnering attention for it's innovative use of 3D modular wood construction a revolutionary approach in an industry traditionally dominated by concrete and steel. Fabricated off-site in a factory, the CLT modules are arranged between two CLT elevator cores to form a 13-storey structure, marking the world's first carbon-negative timber building.

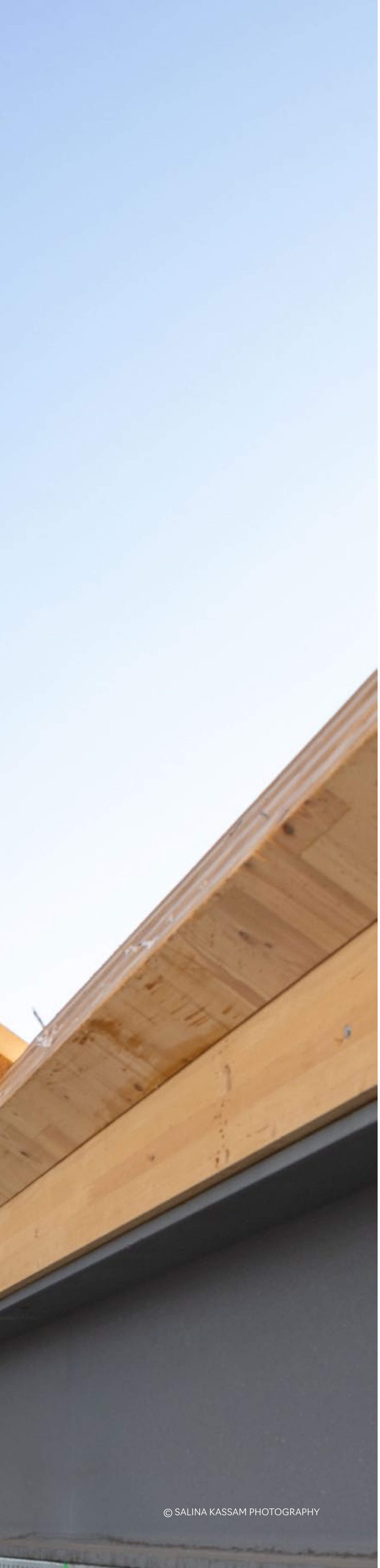
One of the biggest challenges of the project was to convince people to build something that had never been built before. But by harnessing our will and ambition to innovate in wood architecture and sustainable construction, we have now completed the project with an all-wood structure, explains Robert Schmitz.

In contrast, the low-rise building is constructed with glue-laminated timber (glulam) columns and beams and CLT shear walls. An integrated architectural design circumvented the need for reinforced concrete in the load-bearing structure, expediting construction and substantially curbing the carbon footprint.

The ecological merits of the project are undeniable. Employing local, lightweight wood not only saves time and money but also diminishes the environmental impact of transportation. What's more, the prefabricated section increased safety on-site while speeding up construction, making it possible to offer leases a year sooner than expected for a comparable commercial project.



AERIAL VIEW OF THE CONSTRUCTION OF THE SARA CULTURAL CENTRE



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Limberlost Place: Green design with mass timber in Toronto

This project was spearheaded by George Brown College, whose objective was to build a net-zero energy building.

Setting ambitious net-zero carbon emission goals for a high-rise building poses a significant challenge, but the use of solid wood is a critical asset in achieving this vision. Enter Limberlost Place, a 10-storey building along Toronto's waterfront in the East Bayfront Precinct. This project distinguishes itself with its commitment to pioneering ecological design, with mass timber as its primary structural component.

Jay Zhao, Associate at Moriyama Teshima, the architectural firm managing the project, explains that George Brown College outlined four core tenets for this initiative: reducing carbon emissions, attaining net-zero carbon emissions, ensuring future-proof design and creating an smart building. Accomplishing these objectives within an exposed mass timber structure, the first of its kind worldwide, was a formidable challenge but one that has paid off in spades. This endeavour required continuous collaboration, not only within the joint Acton Ostry team in Vancouver, but also with an extensive group of consultants.

Innovative use of solid wood

The choice of mass timber is a cornerstone of this project. This material boasts the advantage of storing carbon, which is lacking in materials like steel and concrete, while also offering exceptional longevity. The building's structure rests on an innovative wood-concrete composite slab system. This system utilizes a concrete slab cast over the CLT panel ceiling, spanning 9.2 metres, effectively replacing conventional beams typically situated between columns. This approach yields a linear ceiling while reducing the height between floors within the building.

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LIMBERLOST PLACE BUILDING UNDER CONSTRUCTION

LIMBERLOST PLACE ARCHITECTURAL RENDERING

"LIMBERLOST REPRESENTS A REMARKABLE FEAT OF INNOVATION, YET OUR ASPIRATION IS FOR IT TO BECOME COMMONPLACE."

PHIL SILVERSTEIN
MORIYAMA TESHIMA

The project's standout feature is the prefabricated facade, composed of large prefinished aluminum panels from Morin affixed with thermal clips. These panels contain integrated glazing for optimal thermal performance, safeguarding the wood and facilitating swift building closure through watertight panel joints, eliminating the need for exterior caulking and enhancing system durability.

Decarbonization and green design

In addition to the wood structure, the Limberlost Place project embraces a holistic approach to decarbonization. Natural ventilation and daylighting systems reduce reliance on energy sources for heating, cooling and lighting.

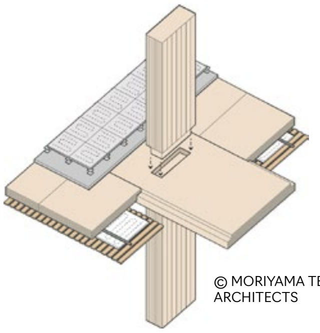
Innovative solutions such as deep water cooling sourced from Lake Ontario are integrated to minimize the building's operational carbon footprint. Additionally, solar panels atop the roof and two natural solar chimneys promote air circulation within the building by drawing air upwards.

Embodied carbon reduction is another pivotal aspect of the project, and the use of mass timber as the primary material allows for carbon to be stocked rather than released into the atmosphere.

Carol Phillips echoes the architectural vision of colleague Phil Silverstein, Contract Administrator and Project Manager at Moriyama Teshima: Limberlost represents a remarkable feat of innovation, yet our aspiration is for it to become commonplace.

MOCK-UP OF THE SLAB USED IN THE CONSTRUCTION OF THE BUILDING

3D VISUALIZATION OF AXONOMETRIC DETAILS



© MORIYAMA TESHIMA ARCHITECTS

Scandinave, using wood for insulation

MARTIN LARUELLE
PUBLIC COMMUNICATIONS
STUDENT, CECOBOIS

Scandinave is a multi-residential building which stands out thanks to its innovative architecture, cutting-edge insulation and use of bio-based materials.

"OUR INCLINATION TOWARD LIGHT-FRAME CONSTRUCTION ALIGNS SEAMLESSLY WITH OUR VISION. WE FIRMLY BELIEVE IN ITS MULTIPLE ADVANTAGES, BOTH ENVIRONMENTAL AND ECONOMIC. BY MINIMIZING THE USE OF MATERIALS WHILE ACHIEVING OPTIMAL INSULATION, WE STRIKE A HARMONIOUS BALANCE BETWEEN EFFICIENCY AND RESOURCE CONSERVATION."

GUILLAUME FAFARD
PRINCIPAL ARCHITECT, QUINZHEE

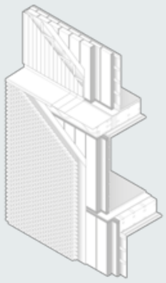
The incorporation of wood into construction, coupled with a calculated approach to building construction, offers numerous advantages. The Scandinave project in Quebec City sets itself apart by using an approach that is both ecological and innovative from the outset. A standout feature is its use of a double timber frame positioned to optimize the building's energy efficiency and insulation. This serves as a testament to wood's capacity for innovation, enhancing fundamental building features.

Scandinavian efficiency

The integration of wood into the Scandinave project offers a host of benefits that embody a commitment to innovation and environmental stewardship. One characteristic of this building is its double-frame construction, an approach that significantly enhances its energy efficiency. The increased thickness of double-wood frame prevents internal heat from dissipating, bolstering the building's overall insulation. Guillaume Fafard explains that the team's inclination toward light-frame construction aligns seamlessly with their vision. They firmly believe in its multiple advantages, both environmental and economic. By minimizing the use of materials while achieving optimal insulation, they are able to strike a harmonious balance between efficiency and resource conservation.

To optimize insulation, the recommended envelope composition includes ISOCLAD on the interior side, cellulose insulation between the studs in select areas and continuous ISO R Plus Premium panels on the outside of the framing. In addition to cellulose insulation, the entire project prioritizes the use of bio-sourced materials, such as sawn timber, LVL, OSB, and MDF framing panels for the windows.

The use of prefabricated double framing for the exterior walls resulted in a roughly 22% increase in the building's energy efficiency without increasing the carbon impact of materials, as evidenced by a GHG assessment using GESTIMAT/GHGMAT. Integrating cellulose insulation into some of the building and choosing to build the balconies in wood instead of concrete helped offset the additional wood and insulation required for the double-stud construction.



3D VISUAL OF FRAMED WALL

What's more, when compared with a reference building made of reinforced concrete, embodied carbon was reduced by over 75%, without taking into account the additional benefit of carbon storage in bio-based materials.

Lastly, utilizing prefabricated timber components yielded cost savings during construction, streamlining logistics and offering a lightweight foundation solution crucial for the site's soil conditions. This solution proved not only more cost-effective than construction alternatives but also more environmentally friendly, reducing CO_2 emissions.

Exploratory analysis of the embodied carbon of Scandinave

Source: GESTIMAT/GHGMAT

RENDERING OF THE « LE SCANDINAVE » BUILDING

RENDERING OF THE LA PÊCHE TOWN HALL

La Pêche Town Hall: Sustainable construction

Using wood in the La Pêche Town Hall construction project was more than a choice. It was a deliberate decision driven by one clear goal: to significantly reduce the building's carbon footprint.

The mass timber building with its unique roof is set apart by the team's pursuit of overall energy efficiency and the use of low-carbon, bio-based materials.

A wood building

Cross-laminated timber (CLT) make up nearly the entire building, a choice that mirrors the vision underlying the entire project. Utilizing CLT made it possible to design a self-supporting roof, with no columns or beams, totalling 1,400 m^2 of wood.

The construction of the building envelope was both efficient and sustainable. The foundations rest on a 400-mm-thick slab with a 355-mm-deep bed of expanded polystyrene, which eliminates the need for deep foundations and avoids foundation-level thermal bridges. The exterior walls are made of cedar cladding, wood-fibre panels with cellulose and mineral wool insulation between the studs. Unlike a traditional building, what makes it airtight is primarily the 19-mm plywood with sealed joints, avoiding the need for a vapour-barrier membrane. This overall design ensures a strong, energy-efficient building envelope.

The project also highlights the importance of prefabricated wood and the incorporation of local materials, making it quicker to complete the building and reducing the risk of potential cost overruns owing to late completion.

The art of decarbonization

From the very beginning of the La Pêche Town Hall construction project, one of the guiding principles was to significantly reduce the carbon footprint and draw inspiration from the Passive House concept. In the pre-project phase, decisions were made with a specific focus on reducing environmental impact, notably regarding concrete usage. However, the decarbonization strategy necessitated careful choices and close collaboration with the customer and the consultants.

With simplicity as the primary focus, the architectural design embraces a streamlined approach, eschewing complexities in favour of a clean-cut structure. The La Pêche Town Hall project is a compelling example of how decarbonization can be attained through a mix of simplicity, top-notch construction and proactive collaboration.

Opting to use bio-based building materials also considerably reduced the building's embodied carbon footprint. For example, the use of a solid wood structure reduced GHG emissions by 131,774 kgCO_2 as compared with a steel structure. This translates to a 40% reduction for the structure as a whole and a reduction in GHG emissions of over 65% for the superstructure, given that the foundation slab is similar in both scenarios assessed.

Building for sustainability

The construction techniques used in this Town Hall project embody a forward-looking vision. The choice to use Eastern cedar exterior cladding was made with durability in mind, as it's known for its long-lasting strength that will ensure a long life for the building. Passivhaus-certified wood-framed windows cladded with ventilated aluminum reduce potential condensation issues.

Dominique Laroche, the architect in charge of the project for BGLA, confidently explains the building's sustainability.

Ultimately, this project and long-term vision are proof that sustainability, efficient timber construction and prefabrication can be combined to create a building that has a low environmental impact.

INSIDE THE LA PÊCHE TOWN HALL BUILDING SITE

"I'M CONVINCED THAT THIS BUILDING WILL STAND THE TEST OF TIME. THERE ARE MANY WOODEN STRUCTURES AROUND THE WORLD THAT HAVE LASTED THROUGH THE AGES, INCLUDING BUILDINGS THAT ARE 1,000 TO 1,200 YEARS OLD, WITH THEIR ORIGINAL STRUCTURE STILL STANDING. WHEN WOOD IS PROPERLY VENTILATED AND MOISTURE IS UNDER CONTROL, THESE STRUCTURES HAVE THE POTENTIAL TO LAST FOR CENTURIES."

DOMINIQUE LAROCHE
BGLA

OUTSIDE THE LA PÊCHE TOWN HALL BUIDING SITE

ARCHITECTURAL
RENDERING OF THE TOD


© SOTRAMONT

The *TOD 1*: Focused on sustainable development

The TOD project masterfully embodies its hallmark objective—to reduce its carbon footprint—by extensively utilizing wood materials.

Located in the Bois-Franc District on the island of Montreal, the TOD project is a multi-residential building with 46 residential units on six floors. The intention behind the building is to redefine the standards of residential construction in Quebec. TOD is an innovative real estate development project that supports housing densification built around a public transit station. What's more, the project's masterful use of Mass Timber as a structural material has earned it LEED Platinum certification.

Using wood as a bio-based material

The project's focus is on living spaces that are both functional and spacious. The rooms feature glue-laminated timber beams and columns to create a natural, eco-friendly atmosphere. The decision to use wood as the structural material proved highly successful, expertly combining prefabrication with wood's unique thermal properties to optimize energy efficiency.

Incorporating wood into a housing project makes perfect sense, not only for its energy efficiency gains, but also to create a welcoming atmosphere and improve quality of life through its visual appeal.

According to Guy St-Jacques, president of Groupe DeNeuve Ltée, it's unfortunate that these benefits are often unknown, whether by developers, legislators, architects or engineers, mainly due to a lack of demand.

However, prefabrication and standardization of certain structural elements are paramount.


© SOTRAMONT

INSIDE THE TOD ECO-HOUSING BUILDING SITE

"NOW IS THE RIGHT TIME TO EXPLORE NEW PROSPECTS IN MASS TIMBER BUILDINGS. BY MAKING PROTOTYPES SHOWCASING SOPHISTICATED, ENVIRONMENTALLY FRIENDLY ARCHITECTURE AND PREMIUM FINISHES, THERE'S POTENTIAL TO OFFER COMFORTABLE HOMES AT COMPETITIVE PRICES, ATTRACTING THE ATTENTION OF DEVELOPERS AND GOVERNMENTS."

GUY ST-JACQUES
PRESIDENT OF GROUPE DENEUVE LTÉE

VIEW OF A CLT INTERIOR LOAD-BEARING WALL

Construction methods

The construction techniques used in the TOD project feature a significant technological advance. The structural system utilizes glue-laminated timber (GLT) beams and columns and cross-laminated timber (CLT) panels made from black spruce from Quebec's boreal forests. Factory-made CLT panels serve as floor slabs and shear walls. Supporting the CLT floor slabs are GLT beams pre-drilled at the factory to accommodate piping. This foresight on the part of the designers and manufacturers, coupled with the use of CLT floor slabs, enabled rapid construction (one day per floor as opposed to one week with conventional materials). The beams and columns have been left exposed in the living units.

One notable aspect of the TOD design is the effort to eliminate thermal bridges often found in concrete construction. This focus led to the development of specific technical details for the project, such as an anchor system for cantilevered balconies aimed at preventing the formation of thermal bridges between balconies and floor slabs.

Assessment of GHG emissions done as part of the study with Écohabitation

As part of a collaborative study with Écohabitation, Cecobois conducted an assessment of GHG emissions associated with the manufacture of structural and envelope materials for a TOD-inspired building. The assessment compared the emissions to those of an equivalent reinforced concrete building. The calculated GHG emissions encompassed stages A1 to A3, which include the extraction of raw materials, transportation from extraction sites to plants and the manufacturing of building materials. The assessment also examined various hypothetical compositions for the building envelope, including exterior walls, interior partitions and the roof.

The results of this assessment reveal that the use of a mass timber structure (BLC-CLT) alone, as opposed to a reinforced concrete structure, leads to a 49% reduction in the building's GHG emissions, i.e., 728,888 $kgCO_2e$ (71 $kgCO_2e/m^2$ of total floor area), when compared with a reinforced concrete structure and a conventional envelope. When considering the entire building envelope (exterior walls, interior partitions and roof), using a solid wood structure and a bio-basced envelope for the exterior walls and interior partitions results in a 53% reduction in the building's GHG emissions, or 949,635 $kgCO_2e$ (92 $kgCO_2e/m^2$ of total floor area), compared to a reinforced concrete structure and a conventional envelope.

Innovating, naturally

CYNTHIA BOLDUC-GUAY
FREELANCE WRITER

Using more of nature's materials is the aim of an increasing number of building researchers wanting to make a difference in the construction industry and reduce its environmental footprint. By developing new products and processes that maximize the use of bio-based materials like wood and enhancing certain by-products, we are paving the way for a healthier, more sustainable world for generations to come, while helping growth of a new green economy.

Ever higher

As urban populations grow, densification has become a major concern. This is why there's growing interest in high-rise construction to address these needs while mitigating the environmental impact. Unfortunately, natural materials like wood have long been sidelined because they are combustible. This perception is changing in light of research and development of high-performance products.

We're seeing more and more wood buildings in Canada that are 12 or more storeys, but it's still a very niche market, said Christian Dagenais, lead scientist at FPInnovations and visiting professor at Université Laval. He references Condos Origine, a 12-storey building in Quebec City, and Limberlost Place, a 14-storey building on the campus of an educational institution in Ontario.

Another major finding is that Canada is lagging behind its neighbor to the south in this area, even though both countries base their regulations on the same studies. In the United States, firms can build solid wood constructions with exposed wood surfaces up to 9 storeys, whereas here we're still limited to 6, Dagenais explains. In Quebec, if you want to build a residential or commercial building more than 6 storeys tall out of wood, you must either encapsulate it or apply to the Régie du bâtiment for an equivalent measure. Christian Dagenais concludes that the possibilities are there. He attributes the delay to a straightforward reason: building codes are updated every three years in the U.S., but only every five in Canada.

Dagenais also says that building professionals are not as well trained in fire safety as their European counterparts. Apart from the course he teaches at Université Laval, courses in this field are rare, whereas the subject is more widespread in curricula on the other side of the Atlantic. In Europe, he says, the approach is different: it's based on performance. European professionals must demonstrate that their project meets a series of quantified criteria, while here, we have to use an application for an alternative solution to prove that our solution is comparable to what is set out in the Code. Dagenais believes that this is why fire safety is taught more extensively in Europe.

"IN EUROPE, THE APPROACH IS DIFFERENT: IT'S BASED ON PERFORMANCE. EUROPEAN PROFESSIONALS MUST DEMONSTRATE THAT THEIR PROJECT MEETS A SERIES OF QUANTIFIED CRITERIA, WHILE HERE, WE HAVE TO USE AN APPLICATION FOR AN EQUIVALENT MEASURE TO PROVE THAT OUR SOLUTION IS COMPARABLE TO WHAT IS SET OUT IN THE CODE."

CHRISTIAN DAGENAIS
FPINNOVATIONS

© FPINNOVATIONS

Nonetheless, there is reason to be optimistic, as Dagenais notes an uptick in interest in high-rise timber construction. He says that Quebec and British Columbia, Canada's leaders in wood construction, are even hoping to adopt an approach inspired by American building codes earlier than planned—as early as 2025.

He adds that the discussion doesn't have to be limited to high-rise buildings. There's significant market potential for 3- or 4-storey wood schools, which are currently limited to 2 storeys with a small footprint. Efforts are under way in collaboration with Cecobois and the Régie du bâtiment du Quebec to develop meaningful solutions, says Christian Dagenais.

Just like mechanics

There are many arguments in favour of prefabrication: reduced workforce, faster construction, better product quality, easy disassembly, etc. And this is good news, as prefabrication and wood are a natural fit.

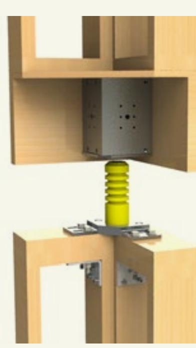
This is particularly true of light timber frame, which is certainly the most efficient and economical system. To make it easier to use, the industry offers an extensive range of innovative, high-performance connectors that make it possible to build structures up to 6 storeys in compliance with building codes. Designers and builders can choose from a range of pre-designed assemblies in stock: heavy-duty self-tapping screws, joist hangers for all types of configurations and even shear wall anchor systems with tie-down systems for mid-rise buildings.

The key is simplicity. The simpler an assembly detail, the less hardware is required, and the easier it is to deconstruct and reuse wood products. This is the principle behind the range of UL connectors. Developed at Université Laval, this self-locking connector is an innovative device for use in prefabricated construction. It works on its own by engaging a permanent lock in the space between the floor and ceiling once the modules have been placed in their final position in the assembly on the work site. The mere weight of the module triggers the locking mechanism, requiring no further manipulation.

A RANGE OF SELF-LOCKING CONNECTORS DEVELOPED BY LAURENCE PICARD, A DOCTORAL STUDENT IN MECHANICAL ENGINEERING AT UNIVERSITÉ LAVAL

The self-locking connector offers other major advantages, including full concealment of the device within the structure, maximized internal module finish, immediate structural stability and a significant reduction in the time required to erect the building. Lastly, the main benefit for industry stakeholders is the substantial cost savings by using the self-locking connector.

This range of self-locking connectors was developed by Laurence Picard, André Bégin-Drolet and Pierre Blanchet to meet the differing structural needs of different floors and buildings. The first connector connects light-frame modules at the corners. The second connector, also designed to assemble light-frame modules, is meant to connect the continuous rod tiedown system to the foundation, enabling these systems to be installed in the factory rather than on site. The third connector attaches to the HD holdowns. By eliminating these two steps, a much higher level of finish can be achieved in the factory, thus maximizing the benefits of prefabrication. Connector development continued following the award of a licence to a marketing partner.



© LAURENCE PICARD

3D VISUAL OF THE UL CONNECTOR. THIS CONNECTION DEVICE CONSISTS OF A MALE PART IN THE SHAPE OF A TOOTHED SHAFT, WHICH IS INSTALLED ON THE CEILING OF EACH MODULE, AND A FEMALE PART LOCATED BETWEEN THE FLOOR BEAMS OF THE SAME MODULE.

A more efficient, natural envelope

After the structure of the building, the building envelope is probably where use of bio-based materials is becoming the most widespread. Some examples include hemp-based insulation, marketed by Nature Fibres, and wood and cedar fibre-based insulation, which is currently being developed at the Chaire industrielle de recherche sur la construction écoresponsable en bois (CIRCERB) in collaboration with FPinnovations and SEREX. Particularly noteworthy are studies carried out by the DeCARB research group, indicating that incorporating bio-based materials results in a greater reduction in buildings' environmental footprint.


© CASSANDRA LAFOND

"FPINNOVATIONS HAS FOUND INTERESTING NEW MARKET POTENTIAL FOR DRY PROCESS PRODUCTS IN ENERGY RENOVATION BECAUSE THEY CAN REACH A THERMAL RESISTANCE VALUE OF R4 PER INCH, WHICH IS ON PAR WITH TRADITIONAL INSULATION, AS WELL AS PROVIDING GOOD ACOUSTIC ABSORPTION."

CASSANDRA LAFOND
FPINNOVATIONS

According to Cassandra Lafond, senior scientist at FPInnovations, the enthusiasm for wood-fibre insulation can be explained by changing codes that require higher energy efficiency, current needs in energy renovation, urban densification, which requires excellent acoustic absorption, the valorization of wood by-products and the reduction of buildings' carbon footprint. There are currently two types of wood-fibre insulation, says Lafond: wet process insulation, which is already used in Quebec and is similar to the papermaking process where water is removed and mechanical strength created, and dry process insulation, with no water, which is currently produced in Europe and has higher R-values.

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THE CLIMATE CHAMBER IN THE CRMR LABORATORIES

FPInnovations has found interesting new market potential for dry process products in energy renovation because they can reach a thermal resistance value of R4 per inch, which is on par with traditional insulation, as well as providing good acoustic absorption. CIRCERB has a climate chamber in which wall mockups with rigid wood-fibre panels are tested to ensure that they provide good humidity removal and don't create condensation. Cassandra Lafond is also interested in building deconstruction. She suggests that a panel could be disassembled and immediately reused in another building, or the existing building could be reconfigured.

Célestin de Serres-Lafontaine, a master's student in wood engineering and bio-based materials, also used the CRMR's climate chamber. As part of his CIRCERB project, he subjected four types of CLT envelope, some with wood-fibre insulation, in different atmospheric conditions. First, a static test was carried out, with temperature and humidity set at 20 °C and 40%, while outside conditions were 10 °C and 80%. In that scenario, says de Serres-Lafontaine, all four configurations showed similar performance. But when he subsequently carried out an analysis where temperature and humidity varied from 10 °C and 90% to 30 °C and 40% every 12 hours, considerable differences began to emerge. He realized that since rockwool is vapour-permeable, a significant layer of moisture forms on the CLT, requiring the use of an air-barrier membrane. But, he explained, since wood fibre absorbs moisture, water movement through the envelope is slowed. These findings call into question whether an air-barrier membrane is needed when using wood-fibre insulation.

But rigid panels aren't the only options being considered for bio-based wood-fibre insulation.

© CÉLESTIN DE SERRE-FONTAINE

BIO-SOURCED CLT ENVELOPES

Enhancing wood panels

A major advantage of optimizing the production of wood composite panels is that we can fully utilize biomass and unused wood residues, says Alain Cloutier, full professor at Université Laval's Département des sciences du bois et de la forêt [Department of wood and forest sciences] and Director of the Wood-Based Composite Panel Research Consortium (Corepan-Bois).

At the moment, some fifteen graduate students have been recruited, mainly from abroad, and will start work this winter. Their research will focus on three main areas: raw materials, processes and adhesives, and products and markets.


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"THE MAJOR ADVANTAGE OF OPTIMIZING THE PRODUCTION OF WOOD COMPOSITE PANELS IS THAT WE CAN FULLY UTILIZE BIOMASS AND UNUSED WOOD RESIDUES."

ALAIN CLOUTIER
UNIVERSITÉ LAVAL

During a consultation with all partners involved in wood processing, especially in the composite panel industry, a consensus was reached on the need to advance research to develop knowledge and train highly qualified personnel. The wood panel industry has been well established in Quebec since the 1980s, but all stakeholders agreed that it was time to improve processes and products, explains Alain Cloutier. This was the driving force behind the establishment of Corepan-Bois, a research consortium at Université Laval, last April. It's funded by the Natural Sciences and Engineering Research Council of Canada (NSERC), the Conseil de l'industrie forestière du Quebec (CIFQ), the Ministère des Ressources naturelles et des Forêts (MRNF), FPInnovations and participating manufacturers: Produits forestiers Arbec, Sacopan, Tafisa and Uniboard. The Université du Quebec en Abitibi-Témiscamingue (UQAT), FPInnovations and SEREX have also joined the research effort.

Students in the first group will focus on maximizing the use of bio-based materials, particularly those made from forest by-products, such as construction, renovation and demolition (CRD) waste, broken stem clippings and forest biomass. Among the bio-based adhesives under development are those made up of lignin, proteins or saccharides derived from agri-food residues and tannins. The idea is to improve processes to store forest carbon for longer in buildings and replace synthetic adhesives made of petroleum products with bio-based adhesives, while creating stronger products with less raw material at a lower cost, explains Alain Cloutier. Interestingly, research will also focus on the development of antibacterial, antiviral and stain-resistant surfaces. Composite panels are likely the solution to forest residues that would otherwise have no other use, as well as to wood recycling, he says.


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COMPOSITE PANELS COPYRIGHT COREPAN-BOIS

"WE MUST REMEMBER THAT INSULATION IS PART OF A SYSTEM; THEREFORE, IT NEEDS TO BE CONSIDERED WITHIN A BROADER CONTEXT TO ENSURE OPTIMAL PERFORMANCE."

PIERRE BLANCHET
UNIVERSITÉ LAVAL


© CIRCERB

Developing a new generation of insulation materials

We need a wider variety of bio-sourced insulation products in Quebec, including insulation batt and rigid panels. We need to make greater use of forest resources and valorize wood chips, says Pierre Blanchet, professor at Université Laval and the NSERC Industrial Research Chair in Sustainable Wood Construction. He believes that Quebec is even lagging behind its counterparts in Europe, where there is currently a great deal of activity in this field. Even if there's more interest here, he explains, we're still in the very early stages. What's holding us back is that there's very little information on the northern climate. As a result, there are still very few bio-sourced insulation materials available.

Among the most promising materials currently being studied are blown cellulose, straw, black spruce bark, bio-refinery materials equivalent to polyurethane and non-textile-grade sheep's wool.

Blanchet often tells his students that the issue is coming up with the greenest solution possible. It often happens that the more we transform raw materials, the less eco-friendly our processes become. We need to keep things simple.

The other important point to consider when working with bio-based insulation is the impact on the entire building envelope. We must remember that insulation is part of a system; therefore, it needs to be considered within a broader context to ensure optimal performance, he says. Since we're moving away from traditional know-how, we need to test the overall implementation. According to Blanchet, insulation made from wood fibre offers several advantages. First, wood fibres are managed sustainably with planned production. What's more, we can take advantage of smart resource management by using sawmill co-products or recycled fibres. Some architects, says Blanchet, also believe that using bio-based wood insulation helps slow thermal shock. While this is true in theory, we have no scientific data to back up this phenomenon in practice in Quebec. It's worth exploring in future research.

Manon Beaufils-Marquet, a Ph. D. student in wood and bio-based materials engineering, is looking to develop alternative solutions to spray-foam insulation as part of CIRCERB's research programme. She's working on alternatives to polyurethane foams, which are petroleum-based. There is already an established standard for this material, explains Beaufils-Marquet. What sets it apart is the choice of cellulose filaments produced by the Kruger company. Based on this standard, she developed a polyurethane spray foam formula and is gradually increasing the amount of cellulose that she adds, initially from 0.5 to 2.5% by mass. It's a very low-density material, so once it's incorporated into the formula, it takes up significant volume even if its mass is small, she explains. However, in her early work, she found that the quality of the polyurethane foam decreased once more than 1.5% of cellulose filaments were introduced. Beaufils-Marquet then sought to chemically modify this foam so that it could replace polyol, a compound that contains several hydroxyl (OH) groups that react with a second product, resulting in polyurethane behaviours characteristic of this type of insulation, much like what is currently being done with soy. The beauty of cellulose, she says, is that it already presents the desired OH characteristics, but these features can be hard to access. The aim is to create a reaction with the cellulose to make these features accessible.


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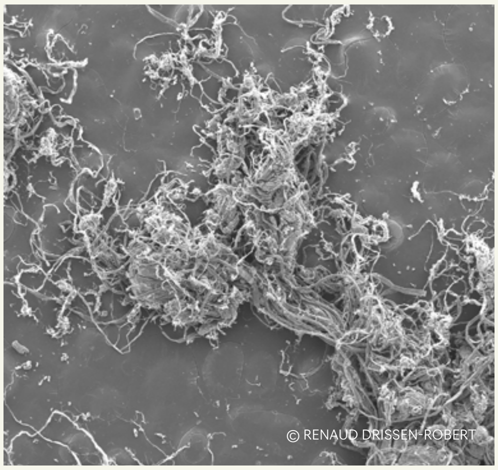
PICTURE OF POLYURETHANE FOAM THAT INCORPORATES CELLULOSE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IMAGES OF CELLULOSE FILAMENTS UNDER SCANNING ELECTRON MICROSCOPE

"WE ARE CURRENTLY WORKING ON CREATING AND TESTING INSULATION MATTRESSES USING SHREDDED CEDAR BARK MULCH TO REPLACE MINERAL WOOL AND OTHER PETROLEUM-BASED INSULATION MATERIALS."

PAPA NIOKHOR DIOUF
CENTRE COLLÉGIAL DE TRANSFERT TECHNOLOGIQUE SEREX

© SEREX

SEREX: Developing new insulation materials from cedar fibres

SEREX, an affiliate of Cégep de Rimouski, focuses its developmental efforts primarily on bio-sourced materials, particularly those that come from wood fibre and other lignocellulosic fibres. Within the domain of eco-construction, SEREX specializes in developing high-performance envelope solutions. These solutions are designed to minimize carbon footprint while enhancing user comfort, addressing aspects such as humidity control, acoustics, and thermal insulation.

In partnership with a cedar shingle manufacturer, they first experimented with cedar bark insulation. Despite its potential as mulch, cedar bark remains susceptible to market price fluctuations. Nevertheless, the bark insulation shows promising thermal performance capabilities. Insulating blankets made from cedar bark or shredded cedar bark mulch offer outstanding thermal insulation, humidity control and thermal inertia. This contributes to enhanced thermal lag in the building, reducing hot spots. Papa Niokhor Diouf also underscores the use of a cedar shingle by-product, which requires less energy for processing than wood chips.

Another interesting avenue explored by SEREX are insulation panels that combine hemp fibres and cedar fibres. Like many other types of bio-based fibre, hemp and cedar bark help regulate humidity in the envelope, avoiding the chance of condensation while providing good thermal insulation. Papa Niokhor Diouf explains that blending the two fibres produces better results, a bit like composite materials. The result of this combination achieves an R factor of 3.5 to 4, which even increased in colder weather, unlike some of the widely available conventional insulation materials.

SEREX is also working to develop greener solutions for treating bio-based insulation against fire and fungus using natural biocides. Recently, the MRNF awarded funding to a number of organizations to design, optimize and test innovative, high-performance building systems with a high content of wood and other bio-based materials.

© SEREX

CEDAR BARK FIBREBOARD

"WE MUST CONSIDER THE CARBON FOOTPRINT OF MATERIALS THROUGHOUT THEIR LIFE CYCLE AND DEVISE PRACTICAL, SUSTAINABLE SOLUTIONS THAT THE INDUSTRYCAN ADOPT TO REDUCE CARBON EMISSIONS IN CONSTRUCTION."

MICHAEL JEMTRUD
MCGILL UNIVERSITY SCHOOL OF ARCHITECTURE

Since 2020, the DeCARB research group based at McGill University has been studying ways to reduce the environmental impact of building operations such as heating, ventilation and cooling. It also studies how to reduce the emissions embodied in the mining, harvesting, processing, manufacturing, transportation, and installation of building materials, in tandem with techniques to sequester carbon emissions in buildings for centuries to come through the use of bio-based materials.

DeCARB: Decarbonizing buildings

One of the group's projects is BARN (Building Architecture Research Node). The new BARN building will be McGill University's first mass timber construction. The 18,000-square-foot research laboratory will be built near the Morgan Arboretum on McGill's Macdonald campus in Sainte-Anne-de-Bellevue. Being on the Macdonald Campus also allows us to selectively harvest wood from the Arboretum to design and construct small demonstration buildings, says Michael Jemtrud, Chair in Architecture, Energy, and Environment DeCarbonized ARchitecture and Building (DeCARB) research group In addition to housing the DeCARB research group, BARN will be tall enough for 2-storey-high wall panels to be fabricated indoors, making it possible to produce full-scale prototypes, test buildings and prefabricated building assemblies for new construction and retrofit.

Jemtrud adds that they are already working to propose high-performance wood envelope solutions for the renovation of the Île-Bizard Community Centre. He explains that this building was chosen for its prefabricated steel structure, which is also found in countless arenas, supermarkets and other commercial buildings, so that the proposed renovation project can be replicated on a larger scale. His team is also working with the Société d'habitation du Québec to find a 3- or 4-storey multi-residential concrete building that will be used to design a renovation scenario for this type of construction.

Salmaan Craig, one of Michael Jemtrud's colleagues, is even looking into natural ventilation solutions. One idea being considered is the use of CLT exterior panels, which allow for ventilation and retain heat.

Naomi Keena, assistant professor at McGill University's School of Architecture and another DeCARB researcher, is interested in the circular economy associated with building materials. She has just written an extensive report on the topic for the United Nations Environment Programme and is also part of an interdisciplinary team whose goal is to facilitate access to data on the entire housing stock in several cities across Canada. This data may be viewed on a web-based, data visualization prototype called Data Homebase, a building passport.. The data will give stakeholders (financial, political and building professionals) the tools to take the circular economy into account in their decisions.

On a different note, Michael Jemtrud is also working with UQAM professor Christian Messier to align the forestry and construction sectors. Jemtrud explains that they are studying climate change models to anticipate forest transformations over time. He anticipates a decline in softwood and emphasizes the need to enhance the forest industry's resilience, possibly by exploring increased use of hardwood species. Similarly, Jemtrud mentions a new research venture with New Brunswick researchers to trace wood from forest to construction, an approach he intends to employ in constructing BARN. Once BARN is completed, says Jemtrud, we intend to directly engage more industrial partners to implement our diverse research initiatives.

CONCEPTUAL DESIGN OF THE BARN FACILITY

Our partners

FINANCIAL PARTNERS

- Ressources naturelles et Forêts Québec
- Ressources naturelles Canada / Natural Resources Canada — Canada
- Conseil de l'industrie forestière du Québec
- Canadian Wood Council / Conseil canadien du bois

GOLD PARTNERS

- Guimond Construction
- Nordic Structures

SILVER PARTNERS

- Art Massif — Structure de bois
- Montmorency — Structures de bois
- Bois Hamel — Expert en structures
- WSP
- FGP
- maibec
- Goodfellow
- Juste du Pin — Revêtements de bois
- rothoblaas
- Soprema
- stgm architecture
- cadwork
- FPInnovations
- Technorm

BRONZE PARTNERS

- EMS
- GLT+
- LC
- lemay
- Pluritec
- Stantec
- Smith Vigeant architectes
- NEUF architectes

FOUNDATIONAL PARTNERS

- ABCP architecture
- Maison Usinées Côté
- Freneco — Expert en structures de bois
- AmeriCan structures
- HBGC ingénieurs
- Crête
- DaVinci structures
- Évolution Structures
- TSTN solutions
- RIVE architecture
- CIMA+
- Laprise
- MTC Solutions
- La Charpenterie
- RBR structures
- BOON Architecture
- Chevrons Vigneault
- Structure du Nord
- Appalaches Solutions Bois
- leclerc
- MAM
- Groupe Genius
- Structures Martel
- CIME
- Cameron
- atelier vert forêt
- Structures St-Joseph / Adam
- Structurex
- St-Georges structures et civil
- WoodzCo
- UsiHome structures usinées
- Clyvanor
- Pro-Fab
- Ultratec
- Structure
- coarchitecture
- Sibe
- MSBQ
- stross
- GLC RVL
- latéral
- Matério
- bgla
- Boise Cascade
- Lepine & Lepine
- Vertima
- Xefor
- Structures Bois Fortin
- StructureCD
- Toiturex
- exp
- Hybrid Joist
- ramo
- Les Charpentistes
- Intra Bois inc.
- Covibro — Murs · Poutrelles · Truss
- Chevron Royal
- Bondu
- Lucie Paquet Architecte
- Sidex