CIRCULAR ECONOMY

& THE BUILT ENVIRONMENT SECTOR IN CANADA

Workshop DISCUSSION PAPER

May 2021

CIRCULAR ECONOMY SOLUTIONS SERIES

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This Discussion Paper shares information and insights sourced from an initial assessment of the current state of the circular built environment landscape and market readiness in Canada in line with global trends and circular economy principles and practices. The initial assessment was carried out by The Delphi Group in collaboration with Scius Advisory, and was completed in March 2021 on behalf of Forestry Innovation Investment Ltd. (FII) and Natural Resources Canada (NRCan) as the co-sponsors for the research.[1]

Discussion Paper Content

DELPHI GROUP

In Partnership with:

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For more information or to get involved with the Circular Economy Solutions Series, contact:

Paul Shorthouse
Managing Director,
Circular Economy Leadership Canada
pshorthouse@circulareconomyleaders.ca

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[1] To download the full report published by The Delphi Group, please visit: https://delphi.ca/publication/circular-economy-the-built-environment-sector-in-canada/

Contents

1. Executive Summary

In Canada, construction is one of the most important economic sectors, generating $141 billion in GDP in 2020. Simultaneously, Canada's construction sector generates one-third of total solid waste in Canada (equal to more than 4 million tonnes of waste per year). Much of the value from these waste materials and resources are currently being lost from Canada's economy at end of life.

Circular Economy & the Built Environment

The circular economy has come to the forefront as a solution for moving away from today's linear 'take-make-waste' economy. Applying circular economy principles to Canada's construction and real estate sector could generate multiple benefits, including reducing waste and greenhouse gas (GHG) emissions; improving the resiliency of supply chains; creating new economic, investment, and employment opportunities; enhancing natural ecosystems and urban green spaces; and providing greater equity and related social benefits.

Circular strategies and approaches applied to the built environment (as shown in **Table ES1**) promote renewable inputs, help keep materials and resources in use for as long as possible, and support resource recovery at end of life in order to recapture the value of the materials that is currently being lost.

Table ES1: Circular economy strategies, approaches, and best practices for the built environment and construction sector.

Strategies	Approaches	Best practices
Circular Inputs & Resource Recovery	Circular inputs	• Renewable energy for powering and heating buildings • Renewable materials (e.g., mass timber) • Recycled content in products (e.g., concrete)
	Eco-design	• Design for disassembly and adaptability (DfD/A) • Design for durability
	Process optimization	• Building Information Modelling (BIM) • Modular construction • Just-in-time construction
	Resource recovery	• Deconstruction • Material recovery • Reverse logistics
Sharing Platforms & Product As a Service	Sharing economy	• Labour sharing • Asset sharing
	Leasing models	• Asset leasing models • Equipment renting
Extending Product Life / Product Use Extensions	Maintenance and repair	• Proactive maintenance (asset management) • Secondary product markets
	Refurbishing	• Flexible building cores (adaptability) • Adaptive reuse

Source: Adapted by the Delphi Group from Circular Economy Global Sector Best Practices Series on Construction, Smart Prosperity Institute (February 2021)

Circularity in Canada's Built Environment Sector

Applying circular building practices in Canada is not new. Construction and demolition waste management efforts, life cycle analysis (LCA) approaches, and material and process innovation practices and policies (including policies that support wood-first approaches) have been adopted by industry and/or governments in many provinces. These efforts have been leading to greater material circulation and lower GHG emissions in the built environment sector.

That said, the built environment in Canada remains one of the largest consumers of raw materials and energy and is also the largest contributor to the waste stream by weight. Efforts to date have largely focused on waste diversion and, to some degree, resource recovery. Very little has been focused on more upstream circular strategies, such as circular inputs and product as a service.

There are a range of stakeholder groups that touch the built environment at various points in the building life cycle that are beginning to drive more circular practices, albeit to varying degrees of adoption. These key stakeholder groups include:

- Architects, designers, and engineers
- Product and equipment manufacturers and suppliers (including modular construction firms)
- Builders and trades
- Property owners, developers, and managers
- Deconstruction firms
- Waste haulers and recyclers

In Canada, circular economy practices and business models are being applied by the leaders in these key stakeholder groups across the various stages of a building's life cycle, as summarized in **Table ES2**. Broader actors, including governments and regulators (at all levels), educational institutions, research agencies and academic thinktanks, industry associations and non-profits, financial institutions and investors, and standards bodies, are important catalysts and supporters of the circular built environment in Canada and make up the enabling ecosystem.

Key Barriers & Enablers for the Circular Built Environment

There are multiple structural and systemic barriers that must be addressed to improve the business case for investing in circular strategies in Canada's construction, real estate, and built environment sector, including:

- Cost challenges of transitioning to a more circular built environment versus the linear status quo
- Lack of awareness / information and standardized definitions
- Fragmentation across construction industries and sectors
- Misaligned policies, incentives, and market signals
- Infrastructure gaps and supply chain issues

Key enablers that can support the circular built environment transition in Canada include:

- Embracing circularity in the design stage
- Education and awareness building
- Supporting cross-sector collaboration
- Developing supportive policy, incentives, regulation, standards, procurement practices
- Supporting business model, process, supply chain, and technology innovation

Table ES2: Current state of circular economy in Canada's built environment sector, by building life cycle stage.

Circular Building Life Cycle Stage	Current State
Circular Building Design	Fundamental to the circular built environment is the need to design well from the beginning, eliminating waste, harmful chemicals, and pollution, while allowing for flexible building use, adaptive reuse, long-term durability, and optimized material recovery. Leading Canadian design and architecture firms are incorporating circularity principles into their projects with the future in mind.
Circular Building Materials & Manufacturing	Canadian industry players have been stepping up in recent years with respect to material innovation and circular manufacturing practices, including off-site and modular construction. Renewable products (such as mass timber) and other innovative materials and products with recycled content (such as asphalt, concrete, steel, carpets, plastics, window frames, and other products) support lower-carbon, circular construction.
Construction	The construction phase of a circular building's life cycle is largely focused on waste prevention onsite, diversion from landfill, and resource management. Leading firms in Canada are focused on onsite waste diversion and management practices during the construction and renovation stages of a building.
Building Use & Operations	Enabling circular building use and operations requires embracing several circular principles and strategies, including design for durability, design for adaptability, adaptive reuse, as well as extending a building or infrastructure asset's life cycle and usage through regular maintenance, renovation, and repair to ensure they can withstand the test of time. Building owners and property managers in Canada are beginning to develop innovative leasing approaches and models that enable more flexible use of real estate but opportunities to go further exist.
Deconstruction & Resource Recovery	Deconstruction is an emerging trend in Canada as firms shift away from the traditional demolition of buildings to recover valuable materials and resources from buildings at end of life and look at secondary markets for these materials, with a handful of industry leaders at the forefront. Currently, the market demand for recovered resources varies depending on the geographic location in Canada and the material type, although in general remains relatively low.
Reverse Logistics	Managing the return and recovery of products and materials from businesses, deconstruction sites, and material recovery facilities back into the value chain through reverse logistics is a key tenet of the circular economy that enables products materials to be recycled, sorted, processed, reused, and remanufactured. Existing waste haulers and recyclers in Canada are well-positioned to enable secondary markets and support more reverse logistics should market demand for recovered materials grow.

Accelerating the Circular Built Environment in Canada

There is a significant economic opportunity for Canada to rethink how buildings are designed, managed, maintained, as well as how construction materials and resources can be more effectively recovered and brought back into the supply chain at end of life to eliminate waste in all of its forms. This, in turn, has the potential to provide additional economic, social, and environment benefits (including GHG emission reductions) – as well as support economic recovery efforts in Canada. Recommendations for advancing circularity in Canada's built environment sector are summarized in **Figure ES1** below.

Focus Area	Recommendation
Embrace Circularity in Design	• Use certification programs to incentivize circular design best practices (e.g., DfD/A, durability, deconstruction) through enhanced point accreditation systems (e.g., LEED and others).
Education and Awareness	• Demonstrate the business case for the circular built environment through case studies, resource toolkits for industry, and knowledge sharing.
Cross-sector Collaboration	• Enhance relationships between building suppliers, builders, and architects to increase shared responsilibities over material use, including through a focus on Integrated Design Processes (IDP) and Integrated Project Delivery (IPD).
Support for Innovation	• Support the adoption of digital innovation in areas such as building information modelling (BIM), building as material banks, and material passports. • Develop an innovation fund and grants to support circula business models and building products and material innovation.
Policy and Procurement	• Develop long-term policies that encourage the scaling of circular solutions, including through procurement practices, to drive market demand. • Transition to more performance-based practices, codes / by-laws, and standards that incorporate circularity.

Figure ES1: Recommendations for accelerating circularity in Canada's construction and real estate sector.

2. Introduction & Background

More than 100 billion tons (U.S.) of raw materials globally are transformed into new products every year. At the same time, only 8.6% of the planet's materials and resources used for these products are cycled back into the economy at the end of their use.[2] Two-thirds of these materials end up dispersed into the environment as unrecoverable 'waste' or pollution – garbage into landfills, plastics into the oceans, carbon dioxide (the 'waste' by-product from burning fossil fuels) into the atmosphere. This linear 'take-make-waste' economy – where resources are extracted, turned into something of use, and then discarded – puts significant pressure on the Earth's ecosystems and exacerbates social inequalities as a result. It also presents enormous lost economic opportunities from failing to recapture the value of these material resources.

The circular economy model allows the full value from these currently 'lost' materials and resources to be maximized throughout their lifetimes by restructuring business models and supply chains, as well as recapturing these materials and resources at end of use. Fundamentally, however, the circular economy is about designing out the concept of waste from products and services altogether.

In Canada, construction is one of the most important economic sectors, generating $141 billion in GDP in 2020. Simultaneously, Canada's construction sector generates one-third of total solid waste in Canada (equal to more than 4 million tonnes of waste per year).[3] Much of the value from these waste materials and resources are currently being lost from Canada's economy at end of life.

Applying circular economy principles to Canada's construction and real estate sector could generate multiple benefits, including reducing waste and greenhouse gas (GHG) emissions; improving the resiliency of supply chains; creating a new economic, investment, and employment opportunities; enhancing natural ecosystems and urban green spaces; and providing greater equity and related social benefits.

As other industries in Canada and globally, such as plastics, look to the circular economy model to address the waste and pollution crisis while promoting long-term sustainability and economic resiliency, the construction sector can look to do the same.

Discussion Paper Contents:

This Discussion Paper brings together the insights from previous research compiled by The Delphi Group. The information is broken out across the following four sections:

- **Section 3: Circular Economy and the Built Environment** – provides an initial high-level overview of the circular economy in the context of the built environment, including global trends shaping the sector.
- **Section 4: Circular Built Environment in the Canadian Context Economy** – provides a summary of circular strategies being applied across a building's life cycle, including circular building design, building material innovation and manufacturing, construction, building use and operations, and deconstruction and resource recovery. It also includes a high-level overview of the enabling ecosystem landscape in Canada.
- **Section 5: Key Barriers and Enablers** – provides an overview of some of the key barriers, challenges, and enablers for a more circular built environment in Canada.
- **Section 6: Accelerating the Circular Built Environment in Canada** – provides a set of recommendations and considerations for future research and efforts to improve the business case for the circular built environment in Canada.

[2] See: https://www.circularity-gap.world/2020

[3] Zahra S H Teshnizi, *Opportunities and Regulatory Barrier for the Reuse of Salvaged Dimensional Lumber from Pre-1940s Houses*.


Nic Lehoux, courtesy naturallywood.com

3. Circular Economy & the Built Environment

In an unprecedented response to the COVID-19 crisis, trillions in economic stimulus are being unveiled worldwide. In the next stage of their recovery plans, governments will have to decide where recovery investment will be allocated. As an instrument to decouple economic growth from resource use and environmental impact, the circular economy opens up the way for a resilient recovery and the next wave of economic prosperity. By fostering innovation and competitiveness, reducing resource dependency and environmental impact, and creating new jobs, the circular economy presents a promising way forward.

The pandemic has laid bare the entrenched shortcomings of the built environment sector, underscoring the prevalence of low-quality buildings, issues around the affordability of decent housing, and the lack of flexibility and adaptability of our current real estate and building stock in Canada. These issues, coupled with the growing concern around the industry's highly wasteful and resource-intensive nature, present a strong impetus for the sector's transformation.[4]

What is the Circular Economy?

The circular economy has come to the forefront as a solution for moving away from today's linear 'take-make-waste' society, addressing growing environmental and social challenges and risks.

The circular economy model aims to:

(1) Design out waste and pollution through upstream interventions;

(2) Keep products and materials in use at the highest value possible throughout their lifetimes; and

(3) Regenerate natural systems.

It provides opportunities to go further in terms of GHG emission reductions by rethinking how resources are used throughout their lifetime and recaptured at end of life, how products can be designed for durability and repairability, and how new services and technologies are leveraged to maximize the usage of assets and 'dematerialize' the need for certain products.

The circular economy model presents new economic and employment opportunities while simultaneously creating more resilient communities, businesses, and supply chains, improving competitiveness and affordability, spurring innovation, and attracting new investment that can support economic recovery.

[4] Ellen Macarthur Foundation, '10 Circular Investment Opportunities for a Low-Carbon and Prosperous Recovery' <https://delphigroup.sharepoint.com/sites/Projects/Shared Documents/Active Projects/Forest Innovation Investment DfDA/Research/Desktop Research/Secondary Reports/EMF The-Built-Environment.pdf?CT=1616950014854&OR=ItemsView> [accessed 28 March 2021].

Circularity Applied to the Built Environment

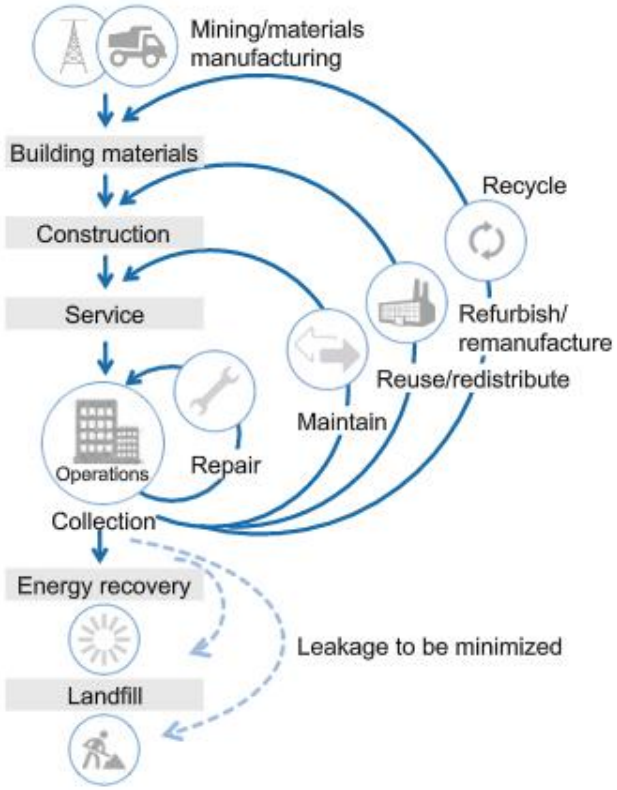
Circular economy principles can be applied to the built environment sector, including construction and real estate value chains, to address current waste issues, recapture lost value, and to realize new economic, social, and environmental benefits. Waste (or lost value) within the construction and built environment sector can be considered across four realms:

- **Wasted resources** (i.e., the use of materials and energy that cannot be continually regenerated);
- **Wasted or underutilized assets** (e.g., buildings that sit empty);
- **Wasted life cycles** (i.e., the premature end of use of buildings given lack of repair, maintenance and/or reuse and adaptability); and
- **Wasted embedded value** (i.e., materials, components, and energy from buildings not recovered at the time of disposal or demolition through deconstruction and material recovery).

Applying circular economy strategies to the construction value chain (as illustrated in Figure 1) through innovative design, maintenance, adaptive reuse, refurbishment, repair, recovery, and recycling, can help to recapture some of this value.

There are five well-established circular business strategies that look to capture the full value of resources and eliminate the concept of 'waste'. These are:

1. **Circular Inputs** – Use of renewable energy, bio-based products, or potentially completely recyclable materials.
2. **Product as a Service** – Offer of a product (or asset) use with retention of the product by the producer to increase resource productivity (e.g., leasing models).
3. **Sharing Platforms** – Increased usage rates of assets through collaborative models for sharing, access, and/or ownership.
4. **Product / Asset Use Extension** – Prolongation of product or asset use through repair, maintenance, upgrading, and resale.
5. **Resource Recovery** – Recovery of usable resources or energy from waste or by-products at end of life.



Source: Ellen MacArthur Foundation; World Economic Forum; The Boston Consulting Group

Figure 1: Circular loops within the construction value chain.

The built environment has broad opportunities for increasing circularity (see Table 1). Circular built environment practices can be used to inform strategies, practices, and business models that help keep materials and resources in use for as long as possible and recover their value at end of life. The opportunities span the entirety of both the supply chain and building life cycle, from buildings and material design, to a building's operations and maintenance, and the end-of-life treatment of buildings and infrastructure.

Table 1: Circular economy strategies, approaches, and best practices for the built environment and construction sector.

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Circular Inputs & Resource Recovery	Circular Inputs	• Renewable energy for powering and heating buildings • Renewable materials (e.g., mass timber) • Recycled content in products (e.g., concrete)
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	Process optimization	• Building Information Modelling (BIM) • Modular construction • Just-in-time construction
	Responsible consumption	• Deconstruction • Material recovery • Reverse logistics
Sharing Platforms & Product As a Service	Sharing economy	• Labour sharing • Asset sharing
	Leasing models	• Asset leasing models • Equipment renting
Extending Product Life / Product Use Extensions	Maintenance and repair	• Proactive maintenance (asset management) • Secondary product markets
	Refurbishing	• Flexible building cores (adaptability) • Adaptive reuse

Source: Adapted by the Delphi Group from Circular Economy Global Sector Best Practices Series on Construction, Smart Prosperity Institute (February 2021)[5]

Global Market Trends

The most considerable environmental impact from the built environment sector comes as a result of lost resources and materials. The greatest impact associated with the construction sector is the ongoing need for virgin resource extraction.

The significant amount of energy and resources required to produce new building materials—extraction, transportation, and manufacturing—also include GHG emissions associated with each stage of making new building materials.

[5] See: https://institute.smartprosperity.ca/sites/default/files/Construction_Best%20Practices.pdf

According to a 2012 U.N. Global Compact and Accenture report[6] approximately half of all extracted raw resources are used to make construction materials, with up to 40% of urban solid waste being construction and demolition waste[7] and 11% of global energy related GHG emissions being attributed to the construction industry.[8] By 2025, it is expected that 2.2 billion tonnes of construction waste will be generated around the world (nearly double the amount of waste in 2018).[9]

The World Economic Forum and Boston Consulting Group note that the construction industry is shaped by two key megatrends that transcend the industry:

- First, 30% of GHG emissions globally are attributable to buildings, with governments having committed to addressing these emissions through net zero building and low-carbon retrofit pathways over the coming decades.
- Second, rapid urbanization is increasing global demand for resources and materials, as well as for affordable housing and infrastructure, placing pressures on the construction industry and its supply chain.

These trends necessitate a rapid transition to more sustainable business practices across the entire sector and will require innovation at new scales within a sector that has historically been a slow adopter of innovation. The circular economy can provide economically feasible, resource and GHG efficient solutions for addressing many of the challenges faced by the construction and real estate sectors, including as it relates to climate action, innovation, and broader sustainability.

Over the last two decades, green building practices have come to the forefront, with standards and certifications that provide a framework for sustainable practices in design, construction, and building management. Part of this has included a focus on reducing building waste, as well as adaptive reuse, including an increasing focus on end-of-life treatment for materials. This is beginning to drive considerations for alternative business models that integrate design for disassembly and adaptability thinking, modular construction, durability, and deconstruction.

The use of mass timber as a sustainable building material has grown dramatically in Europe and Canada. Mass timber can effectively sequester carbon when the full life cycle of wood is optimized. Across the globe, more research is taking place to better understand the carbon sequestration potential of mass timber and other materials. In addition, the life cycle and embodied carbon of products such as mass timber and its production is a work in progress, as well as developing a better understanding for how long wood remains in use.[10] In short, sustainable forestry management is a growing field coupled with an optimized mass timber life cycle in the building sector which poses unique opportunities for the circular built environment.

The growing trends in digital and disruptive technologies are also enabling the circular economy in the built environment through improved productivity, efficiency, process improvements, and enhanced collaboration. Construction technology (or 'contech') refers to the collection of innovative tools used during the construction phase of a project – including machinery, modifications, and software – that enable greater productivity, reduce material waste, and result in higher-performance buildings.[11] Examples include building information modeling (BIM) software, virtual reality (VR), drone technologies, and new digital tools that improve material flow tracking.

[6] 'Options for Waste Reduction and Diversion - Construction Canada' <https://www.constructioncanada.net/options-for-waste-reduction-and-diversion/> [accessed 26 March 2021].

[7] *MAKING BUILDINGS WITH NEW TECHNIQUES THAT ELIMINATE WASTE AND SUPPORT MATERIAL CYCLES CIRCULAR ECONOMY IN CITIES* <www.ellenmacarthurfoundation.org/our-work/activities/circular-economy-in-cities> [accessed 29 March 2021].

[8] *MAKING BUILDINGS WITH NEW TECHNIQUES THAT ELIMINATE WASTE AND SUPPORT MATERIAL CYCLES CIRCULAR ECONOMY IN CITIES*.

[9] Ellen Macarthur Foundation.

[10] 'As Mass Timber Takes Off, How Green Is This New Building Material? - Yale E360' <https://e360.yale.edu/features/as-mass-timber-takes-off-how-green-is-this-new-building-material> [accessed 8 April 2021].

[11] Industry Whitepaper, 'The Contech Ecosystem in Metro Vancouver', July, 2020, 1–8.

Addressing climate change through building energy use has also become a critical focus for many, with a more recent extension to include embodied carbon contained within products and materials by taking a life cycle accounting approach to measuring GHG emissions (i.e., to include accounting for the total GHG emission impacts of a building). Currently, buildings are mainly viewed as contributing to climate change via operational emissions. However, as considerations for consumption-based GHG emissions and life cycle accounting grow, embodied carbon impacts become more important.

Jurisdictions are starting to adopt regulations to address the embodied carbon within buildings and this is resulting in a greater focus on the impacts of materials over their entire life cycles. [12] Annually, embodied carbon is responsible for 11% of global GHG emissions and 28% of global building sector emissions (see Figure 2).[13] It is estimated that embodied carbon will be responsible for almost half of total new construction emissions over the next 30 years to 2050.[14]

The focus on embodied carbon, in turn, is driving the demand for lower-carbon and renewable materials as circular inputs into the buildings and infrastructure, with products such as mass timber and those with increasing amounts of recycled content (e.g., concrete, steel, carpets, etc.) becoming favourable from a climate change perspective. This emerging focus on the upstream components of the building life cycle is presenting new opportunities for the sector using a circular economy lens.

Europe has been embracing circular economy as a model for improving economic competitiveness and resource efficiency while also realizing the environmental and GHG benefits. The EU's Circular Economy Action Plan was adopted in March 2020 as part of the European Green Deal and includes a focus on construction and the built environment.[15]

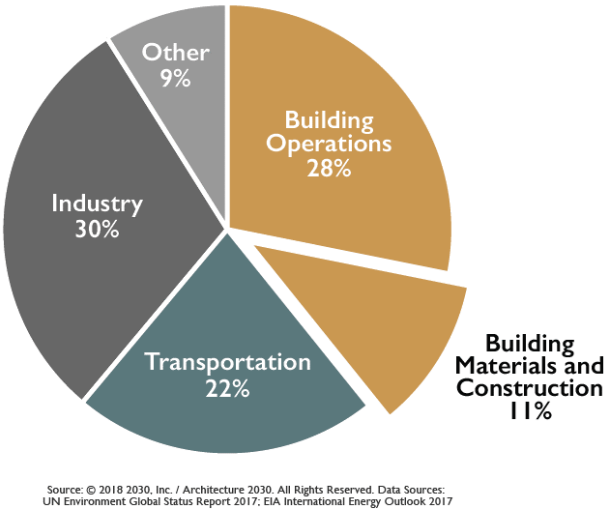


Figure 2: Global GHG emissions by sector.

The value of the materials in buildings is also increasingly being recognized through projects in Europe such as the Building as Material Banks (BAMB) program[16] and the concept of material passports, as well as through online marketplaces for trading and selling reclaimed materials. BAMB and its material passport initiative are designed to track and save materials used in the building process, linked to a digital document that chronicles the precise materials used in a particular building. The material passport additionally notes which materials used are best positioned for recovery and reuse, by highlighting which areas of the building are most valuable for construction purposes through the notation of their quality and maintenance.

While the Canada Green Building Council has identified circular economy as an emerging trend for the built environment sector for the coming decade, it also recognizes that "success will depend on industry innovation and the ability to accept and overcome political trade-offs and broader societal challenges, including behaviour change".[17]

[12] Zizzo Strategy Inc, Brantwood Consulting, and prepared for Forestry Innovation Investment Ltd, *Report: Embodied Carbon of Buildings and Infrastructure: International Policy Review*, 2017.
[13] See: https://architecture2030.org/new-buildings-embodied/
[14] 'New Buildings: Embodied Carbon – Architecture 2030' <https://architecture2030.org/new-buildings-embodied/> [accessed 8 April 2021].
[15] See: https://ec.europa.eu/environment/circular-economy/
[16] See: https://www.bamb2020.eu/
[17] See page 81: https://www.cagbc.org/cagbcdocs/advocacy/CaGBC_CanadasGreenBuildingEngine_EN.pdf

4. Circular Built Environment: The Canadian Context

The built environment in Canada is one of the largest consumers of raw materials and energy and is also the largest contributor to the waste stream by weight. In Canada, 3.4 million tonnes of construction materials are sent to landfill annually representing an estimated 1.8 million tonnes of embodied carbon.[4]

Research shows that greater material circulation could significantly lower GHG emissions in the construction sector. For example, a report published by the National Zero Waste Council suggests that 1.3 million tonnes of embodied carbon could be avoided per annum if all buildings renovated or demolished in Canada were disassembled and reused.[18]

It is important to note that applying circular building practices in Canada is not new. Construction and demolition waste management efforts, life cycle analysis (LCA) approaches, and material and process innovation practices and policies (including policies that support wood-first approaches) have been adopted by industry and governments in many provinces. These efforts have been leading to greater material circulation and lower GHG emissions in the built environment sector. That being said, over the last several decades, efforts have largely focused on waste diversion and, to some degree, resource recovery. Very little has been focused on more upstream circular strategies, such as circular inputs and product as a service.

In the early 2000s, organizations such as the Canada Green Building Council, the CSA Group, and others were convening stakeholders and working on various related initiatives, including linking efforts to green building standards and certification programs such as Leadership in Energy and Environmental Design (LEED). In fact, since 1995, the CSA Group has developed three standards or guidelines that are highly-relevant to circular economy practices in Canada's built environment sector. These are:

1. **CSA S478:19 Durability in Buildings**[19] - Released in 1995 and updated in 2019 (referenced in LEED Canada for Durable Building Credit).
2. **Z782-06 Guideline for Design for Disassembly and Adaptability in Buildings**[20] – Released in 2006.
3. **Z783-12 (R2016) Deconstruction of Buildings and their Related Parts**[21] – Released in 2012 and updated in 2016.

It is fair to say that the market potential for circular economy solutions in Canada is large, and awareness and interest are growing with industry, governments, academia, and others. There are a range of stakeholder groups that touch the built environment at various points in the building life cycle (as illustrated in Figure 3) that are beginning to drive more circular practices, albeit to varying degrees of adoption.

These key stakeholder groups include:

- Architects, designers, and engineers
- Product and equipment manufacturers and suppliers (including modular construction firms)
- Builders and trades
- Property owners, developers, and managers
- Deconstruction firms
- Waste haulers and recyclers

[18] See: http://www.nzwc.ca/Documents/NZWC-WastePreventionReport.pdf
[19] See: https://www.csagroup.org/store/product/CSA%20S478%3A19/
[20] See: https://www.csagroup.org/store/product/2702528/
[21] See: https://www.csagroup.org/store/product/2703337/

Broader actors, including governments and regulators (at all levels), educational institutions, research agencies and academic think-tanks, industry associations and non-profits, financial institutions, and standards bodies, are important catalysts and supporters of the circular built environment in Canada and make up the *enabling ecosystem*.

There are many relevant examples of circular built environment / construction initiatives and businesses in action. Across Canada, the provinces of British Columbia, Quebec, and Ontario are hubs for circular built environment initiatives and increasing levels of related innovation. Many industry leaders are focusing on the design challenge of embeding circular practices at the beginning of the building's life cycle process. However, given the fragmented nature of the construction sector, there are significant system barriers and existing inertia that must be overcome.

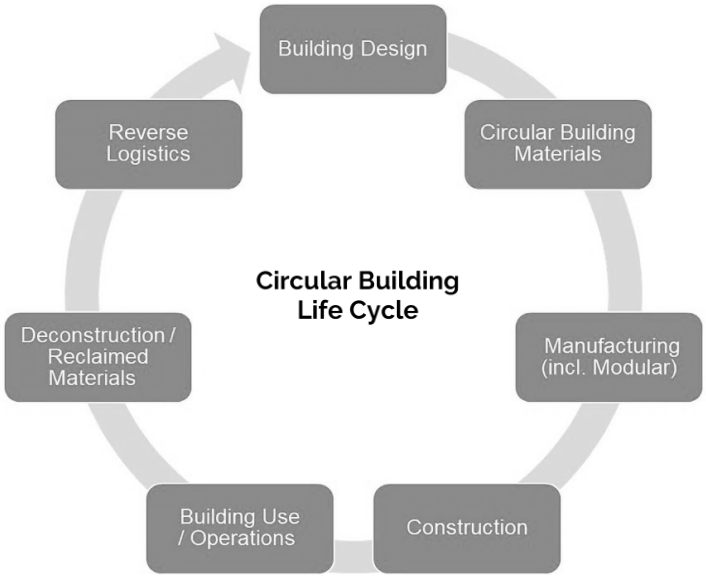


Figure 3: The circular building life cycle.

The following sub-sections profile examples of the current state of circular built environment practices and initiatives across Canada, using the circular building life cycle (depicted in Figure 3) as a framework for discussion purposes.

Circular Building Design

Fundamental to the circular built environment is the need to design well from the beginning, with the concept of eliminating waste, as well as allow for flexible use, adaptive reuse, long-term durability, and optimized material recovery. Many Canadian design and architecture firms are incorporating circularity principles into their projects with the future in mind.

The Royal Architectural Institute of Canada, a leading voice in the built environment, notes the increased emphasis in the sector to design holistically, eliminate waste, and support the rapid transition to circular economy. Designing for whole-life-cycle value, by approaching projects as value-adding investments in regenerative economies, is emerging as best practice in the leading architecture and design community – although a broad adoption of this philosophy is not yet wide-spread.[22]

The new mindset dramatically changes the practice of architecture and the craft of design, most especially by requiring professionals in the field to rethink the way buildings are put together so that the materials can be disassembled and reused, maintaining both their resource and carbon value. It also places a larger emphasis on the entire life cycle of building and site materials, setting the stage for the building industry to move from a waste-management model to a circular economy model.

[22] 'Designing for the Future | Royal Architectural Institute of Canada' <https://raic.org/raic/designing-future> [accessed 29 March 2021].

Below is a short-list of Canadian leaders as examples:

- **Perkins+Will** is recognized for its commitment to sustainability with a recent pledge to deliver net zero interiors by 2030, putting circular design firmly at its heart.
- **DIRTT** is using advanced, digital technologies such as virtual reality (VR) software to optimize its projects and allow for maximum flexibility and sustainability as part of its lean interior design prefabrication process (see sidebar).
- **BNKC** Architecture and Urban Design has developed Canada's tallest timber office building at eight storeys, located at 77 Wade Avenue in Toronto.[23] The firm's design exceeded the current building code in Ontario, and, as such, it was able to work with the City of Toronto to have the project approved through the City's Alternative Solutions Process (ASP).
- **Arup** is a global firm that is active in Canada with more than 20 building projects. Arup aims to translate the principles of a circular economy into the everyday built environment practices. By designing-in flexibility from the start, Arup seeks to ensure better returns on investment for building owners.
- **HDR** is transitioning the building design practice from static to dynamic, and from fixed to flexible. By pursuing hybrid mass timber structures with steel lateral braces instead of the typical steel and concrete structure, HDR is addressing embodied carbon and enhanced the interior environment.
- **Henriquez Partners Architects** is designing a 21-storey rental tower, exploring two possible mass timber hybrid systems: a post and platform system and a post, beam, and panel system.
- **GSky Living Green Walls**, based in Vancouver, B.C., is a global provider of living walls, vertical gardens, and green walls tailored to fit both interior and exterior green wall designs – aligning with the regenerative nature of circular economy principles.

CASE STUDY: DIRTT's Circular Design for Interiors

DIRTT (Doing It Right This Time) is a publicly-traded OEM (TSX: DRTT) with manufacturing facilities in Kelowna, B.C., Phoenix, Arizona, Savannah, Georgia, and Calgary, Alberta, where their Corporate Headquarters are co-located. Their core product offerings are structural interiors intended for commercial, institutional, and business customers conducting new builds and/or renovations: their products provide designers, architects, office tenants / lease-holders, and other construction industry actors with a wealth of design and material options, all completely customized for every project.

DIRTT's core value proposition is based on what can be saved in terms of materials, costs, and time during a construction or renovation project. Prefabricated custom components arriving on-site in a 'ready to install' state can prevent a myriad of complications and costs common during construction. These include, but are not limited to, mistakes in measurements or cuttings resulting in 'start-overs' or the need for new/replacement materials and site congestion. Scheduling overlaps where multiple tradespeople wind up working 'over top' of each other, thereby decreasing efficiency and increasing costs, clients who are surprised by or dissatisfied with how things look (thereby triggering new 'start-overs' and re-designs) and so on.

To address costly on-site complications, DIRTT products are carefully designed, planned, and manufactured to spec: they do not hold 'ready made' inventory. DIRTT's proprietary ICE planning software generates VR models of customers' spaces, overlaid with various DIRTT products and materials within the VR model. This allows customers or their designers (i.e., interior designers) to test various configurations, colours, textures, and structures before anything gets manufactured. Once the overall aesthetic and design have been approved, the ICE platform immediately triggers JIT work orders to fulfil the project needs at the exact specifications used in the VR model.

[23] See: https://www.bnkc.ca/project-spotlight/77-wade-avenue/

Design for Disassembly and Adaptability (DfD/A) specifically supports circularity in the built environment by promoting innovative design practices aimed at lengthening the lifespan of a building. It applies a systems-thinking approach whereby the project team must consider the full life cycle of the building and its materials.[24] As such, DfD/A is all about "planning with the end in mind".

Design for Disassembly and Adaptability (DfD/A) can be defined as the process of designing structures such that they can be disassembled into component parts to be repurposed for future activities.

The primary benefit of DfD/A is that it allows for individual components of buildings to be more easily reused when the buildings are dismantled, as an alternative to demolition and landfilling, with the potential to reduce construction related waste streams. To be successful, DfD/A relies on minimizing and standardizing parts and fasteners, where possible, and avoiding glues and adhesives, which create irreversible connections.[25]

Wood products (and designing with wood) are well suited for DfD/A, Wood products can be altered to standardized or modularized forms supporting the DfD/A process. Wood also lends itself to a broad area of reversible fasteners and can be finished with sustainable products facilitating reuse at the end of building or component life. Relatively little energy is needed for the manufacture and processing of wood construction materials compared to alternatives such as concrete and steel. Typically, wood-based products use mainly biomass residues for processing energy and have lower climate impacts than alternatives.

Although DfD/A guidelines were developed by CSA Group in Canada starting back in 2002 and have formed the precursor for the ISO Standard released in 2020, there has been minimal adoption of this practice in Canada over the last two decades except for a handful of projects.[26] Examples include:

- **Mountain Equipment Co-op Stores** (multiple locations) - Mountain Equipment Coop (MEC) has four buildings across Canada that showcase circular building practices and building material stewardship, with the flagship Ottawa building is recognized for a model for DfD/A in Canada since its original construction more than 20-years ago (see sidebar).
- **C.K. Choi Building** – Based in Vancouver, B.C., this award-winning building was designed in 1996 by Matsuzaki Wright Architects Inc. and is home to the University of British Columbia's Institute for Asian Studies. It is recognized for extensive material salvage and reuse, in addition to applying principles of DfD/A.
- **DIRTT** - Headquartered in Calgary, Alberta, since 2005, DIRTT has been applying DfD and reuse strategies for its prefabricated building interiors.
- **3XN** – Danish architecture firm 3XN is an international leader on DfD/A and has projects in Toronto, including the T3 Bayside complex that is part of the Waterfront Toronto development.[27]

Additional examples include retail stores, supermarkets, aircraft hangars, and federal government buildings (including Department of National Defence and Public Services Canada).

While theoretical awareness exists with Canada's design community, the actual adoption and demand from building owners and developers remain low. As such, the industry has yet to respond in terms of developing construction best practices, investing in material and component innovation, or supportive policy and educational / training resources.

Recent growth in offsite and modular construction in Alberta, B.C., Quebec, and Ontario, as well as green

[24] https://www.ellenmacarthurfoundation.org/assets/downloads/news/EMF_Engineering-the-Circular-Economy_300913.pdf

[25] See World Business Council for Sustainable Development (WBCSD). 2018. Design for disassembly/deconstruction. https://www.ceguide.org/Strategies-and-examples/Design/Design-for-disassembly-deconstruction#:~:text=Design%20principle%20that%20calls%20for,and%20materials%20can%20be%20deconstructed.&text=It%20can%20also%20help%20ensure,whole%20components%20to%20be%20reused.

[26] Estimates by experts provide through key informant interviews for this project suggest approximately 20-25 buildings in Canada have effectively applied DfD/A principles.

[27] See: https://3xn.com/project/t3-bayside

roof deployment in locations such as Vancouver and Toronto that include simple layers to reduce contamination of fusion of materials, has required DfD/A thinking. This is because offsite and modular construction requires the ability to assemble and disassemble projects – including multiple layers, components, and subcomponents – while also allowing for flexibility.

Given some limitations around the use of precast concrete and steel, the adoption of mass timber and bylaws in Canada that favour wood construction are also well aligned to enable more DfD/A projects in the coming years. Further, the move away from many mechanical connections in buildings, as well as the adoption of digital technologies in design processes (such as BIM) in Canada, is further enabling adaptive reuse and flexible building design concepts to be brought forward.

Corporate Leadership in DfD/A: Case Study on MEC

Mountain Equipment Coop (MEC) has four buildings across Canada that showcase circular building practices and building material stewardship. The first two are the Ottawa and Winnipeg buildings, both of which were built to C2000 standards at the time. C2000 was the predecessor of LEED and other building performance metrics, the buildings being classed the 1st and 2nd ever C2000 certified in Canada.

The **Ottawa building** is recognized for a model for DfD/A. The original 40-year old building was carefully dismantled with the intention of reusing as much material as possible, utilizing the disassembly-friendly original construction components. As a result, roughly 75% of those materials were re-incorporated into the new building, including 50% of the timber, and the majority of the steel building frame. Key participants in this project were Derek Badger, who went on to author "The Residential Deconstruction Manual" for the CHMC, and Linda Chapman Architecture.

An important aspect of this project was the preservation of heritage features of the building, a 60's era two-storey grocery store with curbside character contributing to the area's heritage and aesthetic. Critics of the project implicated MEC as adding to the 'gentrification' of the area, preserving heritage elements that much more important.

Source: https://www.mec.ca/en/explore/green-buildings

Circular Building Materials & Manufacturing

Canadian industry players have been stepping up in recent years with respect to material innovation and circular manufacturing practices. Renewable products (such as mass timber) and other innovative materials and products with recycled content (such as asphalt, concrete, steel, carpets, window frames, and other products) support lower-carbon, circular construction.

The importance of embodied carbon has been enabled by rigorous quantitative modelling that tracks carbon emissions across the full life of materials and products, using life cycle assessment (LCA). In recent years, the Canadian building industry has adopted LCA as the globally accepted method for evaluating and communicating environmental impacts and applied these methods to the study of materials, products, and assemblies.

A life cycle assessment is a methodology used to measure the impact that a product or process has on the environment, from the beginning of the process (raw material extraction) to the end of the process (disposal). These assessments can be used to analyze anything from building materials to furniture. LCAs are used to measure both material and energy inputs and outputs, evaluate the effects of those inputs and outputs and formulate the data into useful information for understanding the outcome of a particular product or process on the air (i.e. ozone depletion), land (i.e. waste) or water (i.e. pollution).[28]

Gestimat is a LCA tool developed in Quebec. It is used for estimating GHG emissions linked to the manufacture of structural materials, which makes it possible to compare different building scenarios in a Quebec context. The modeling of scenarios can be done using the estimation of the quantities of materials according to typical buildings or by entering quantities of materials specific to a given project. Gestimat also allows the various provincial ministries and organizations to share the data from their GHG analyses with the Ministry of Forests, Wildlife and Parks of Quebec (MFFP).[29]

Another important consideration for circular products and materials are Environmental Product Declarations (EPDs). EPDs are third-party verified documents that incorporate LCA and other environmental considerations (e.g., chemical compounds such as VOCs), written in conformance with international standards, and act as labels on products and materials to help identify their environmental impact. In Canada, LCA, EPDs, and the Gestimat tool are being used by early adopters such as government bodies and private sector companies that support the government with their infrastructure builds.

To reduce the impacts from buildings on the environment, including GHG emissions, building components are being designed to sequester more carbon over their life cycle than they emit. This means: zero energy use operational design; the incorporation of renewable carbon storing materials such as mass timber and cellulosic fiber insulation; site carbon sequestration elements such as green roofs and soil building algae farming; and carbon sequestering concrete.

Building with wood products such as mass timber can reduce the overall carbon footprint in several ways:

- First, wood is a renewable resource. Growing a tree is a low-impact production method (i.e., it uses photosynthesis rather than a plethora of machines).
- Second, trees are grown in abundance all over Canada and do not require importation, reducing the amount of energy expended on shipping.
- Third, harvesting trees allows forests to become more efficient at carbon sequestration. When a tree is harvested, it stores carbon. When another tree is planted in its place, it will also store carbon, making that plot of land's carbon sequestration indefinite.

[28] 'Life Cycle Assessment (LCA)' <https://greenbuildingcanada.ca/green-building-guide/life-cycle-assessment-lca/> [accessed 8 April 2021].

[29] 'About Us' <https://gestimat.ca/about-us> [accessed 8 April 2021].

- Fourth, timber's durability allows it to be disassembled and then reassembled into other buildings and furnishings, sequestering carbon for longer so long as it stays out of the landfill. [30]
- Lastly, assuming wood waste can be diverted from landfills, it can continue to sequester carbon and be turned into various, valuable bio-based products, such as biochar. Biochar can be used to replace coal, as well as for agricultural fertilizer. [31]

Canada is a major wood-producing country, with governments and industry making the link between the economic vitality of the forests sector and renewable bio-based products. Historically, Canada has been an exporter of conventional lumber products. However, over the last decade, there has been a holistic and strategic approach from all levels of government and industry, including investments in research and development (R&D), by industry and governments to enable Canadian companies to become leaders in engineered and value-added wood products and technologies (e.g., cross-laminated timber), as well as related building design and engineering. Canada also has growing expertise in building prefabrication and modular construction, as well as related components and processes.[32]

B.C. and Quebec are leaders in the mass timber construction movement in Canada. In Ontario, the market for mass timber is well-positioned for growth, with building code changes in 2015 enabling 6-storey wood buildings. Ontario's access to wood resources and its proximity to Eastern U.S. states puts the province in a strategic position for export. The Canadian dollar also makes mass timber products more affordable in the United States, giving Canadian manufacturers a comparative advantage.

Offsite and Modular Construction (OMC) is a subset of lean manufacturing that allows both mass customization and process standardization, thus reducing material waste and build time compared to traditional onsite construction techniques. The demand for prefabrication and modular construction is growing in Canada due to its cost savings and shorter lead times for building. It also allows for energy and process improvement that increase overall performance requirements for emerging net zero energy buildings and related codes – performance that is difficult to meet through onsite construction. Below is a short-list of Canadian leaders in mass timber manufacturing and OMC as examples:

- **Element5** is an Ontario-based leader in prefabricated mass timber construction. In 2020, Element Five completed the construction of the Oakville fire station in Ontario.[33] The building used prefabricated components such as cross-laminated insulated panels (CLIPs). CLIPs are a customizable building envelope solution that reduces material use and construction time, and increases site safety and project sustainability.
- **Structurlam**, based in British Columbia, was the first manufacturer of cross-laminated timber (CLT) in North America, and is the first Canadian manufacturer of CLT to be certified to the SFI 2015-2021 Chain-of-Custody Standard. Structurlam blends the expertise of wood science with the ingenuity of European fabrication to produce mass timber products, in cluding CLT.
- **Kalesnikoff**, based in British Columbia, have an integrated business model similar to companies in Europe. They are able to saw their own stock for CLT and glulam, maximizing lumber yield and profit while minimizing waste.
- **Nordic Structures** is a leading example of a company that has embraced modular structures that can adapt to the changing demographics in a community and allow for adaptive reuse (a key circular strategy). Its modular mass timber structures provide turnkey solutions that allow building owners, such as school boards, to adjust over time to meet their needs. As communities change and population demographics shift, their modular classrooms are helping administrators contend with student surpluses and provide much-needed space during school renovation and construction

[30] 'Is Mass Timber Really Sustainable?' <https://www.archpaper.com/2017/11/timber-construction-sustainable/> [accessed 8 April 2021].
[31] 'Home | BC Biocarbon' <https://www.bcbiocarbon.com/> [accessed 8 April 2021].
[32] Canada Green Building CouncilThe Delphi Group, *GREEN BUILDING IN CANADA Assessing the Market Impacts & Opportunities*, 2020 <www.cagbc.org> [accessed 10 March 2021].
[33] See: https://elementfive.co/project/oakville-fire-station-8/

projects. Once the community population ages, the school boards can relocate these modular classrooms to neighbourhoods that need them.

- **3HD Panels** is a prefabricated wall panel supplier based in Alberta. Their prefabricated wall panels are manufactured in a 18,000 square ft. facility using laser technology to ensure consistent quality and fit. The panels are then deliver to the construction site as a complete package, reducing waste, construction delays, which allowing project to be built faster and more efficiently.
- **BuiltPrefab** designs, manufactures, and installs premium prefab modular buildings. This company actively uses cross laminated timber.[34]
- **Intelligent City** offers a turnkey solution to multi-family housing through the convergence of mass timber, automated manufacturing, and proprietary parametric software. Using mass timber in a turnkey, automated production process, Intelligent City has developed a fast, de-risked, and cost-efficient process for the design and delivery of urban housing projects called Platforms for Life.

Cardinal Prototype house is a prototype for a prefabricated mass timber home intended to help meet the housing needs of First Nations communities. Cardinal – along with a skilled team of construction professionals – designed, prefabricated and assembled the first Cardinal House, a prototype that was completed in October 2020 for the Elsipogtog First Nation in New Brunswick.

The 1,100-sq.ft. two-storey, three-bedroom/two-bathroom Cardinal House is a high-performance, mold-resistant mass timber design. Manufactured off-site to exacting standards in a controlled indoor environment, then shipped on a single truck and assembled by a small crew in just a few days, Cardinal House is an affordable solution that uses modern materials and methods to successfully address many of the key issues contributing to the housing crisis.

[34] See: https://builtprefab.com/the-product/

Beyond mass timber and engineered wood products, products and materials with reclaimed and circular inputs, such as recycled content, are helping reduce GHG emissions and divert waste from landfill, as well as saving builders disposal or tipping fees. Products such as recycled concrete can also reduce transportation costs because concrete can often be recycled in areas near the demolition or construction site. It is commonly used as a base for roads, parking lots, and driveways, as well as recycled stone, backfill material, and shoulder stone.[35]

Researchers at UBC Okanagan's School of Engineering conducted side-by-side comparisons of recycled and conventional concrete within two common applications—a building foundation and a municipal sidewalk. They found that the recycled concrete had comparable strength and durability after five years of being in service.[36]

The integration of recycled plastics is another example of circular building materials being manufactured in Canada today. Recycled plastics can be blended with virgin plastic to reduce costs and improve environmental benefits, without sacrificing performance. Recycled plastics are used to make polymeric timbers for use in everything from picnic tables to decking and fences. In addition, recycled plastic feedstock from beverage containers are being spun into fiber for the production of carpet in building interiors.

Below is a short-list of Canadian leaders in recycled content construction materials as examples.

- **Lafarge** is a leader in recycled product manufacturing and has employed a successful recycled asphalt program (RAP) delivered in partnership with the National Zero Waste Council and the City of Richmond.[37] Lafarge is also a leader in recycled concrete and has found that it can perform better than conventional concrete in many cases.
- **CRH Cement** turns site waste into cement by producing and processing cement-based materials such as construction shale as raw material feed; petcoke utilization; recovery of waste oils/solvents; and CRH Slag Cement.
- **CarbonCure** is a unique company dedicated to make concrete a climate solution and reduce embodied carbon in the built environment by 500 megatonnes annually. They have developed three products that reduce GHG emissions; CarbonCure for Ready Mix, CarbonCure for Precast, CarbonCure Masonry.
- **Viking Recycling** is a recycling and environmental services company, which specializes in diverting heavy, durable materials from landfills.[38] Based in Ontario, the company specialize in carpet recycling and have recently released a unique line of carpets and fibres.
- **Full Circle Plastics** works with local businesses and municipalities to source recycled plastic from around Alberta and neighbouring provinces and manufacture it into recycled plastic lumber. Plastic lumber has a large variety of uses from nailer board, fence posts, and bollard posts, to furniture and garden boxes.
- **Dinoflex** makes flooring out of old rubber tires and have been early pioneers of recycled construction materials used as soft matting in playgrounds and in other applications.

[35] 'The 411 on Recycled Concrete: Uses, Benefits, and How To | Ozinga' <https://ozinga.com/blog/the-411-on-recycled-concrete-uses-benefits-and-how-to/> [accessed 25 March 2021].

[36] 'New UBCO Research Suggests Recycled Concrete Could Be a Sustainable Way to Keep Rubble out of Landfills' <https://news.ok.ubc.ca/2020/11/30/new-ubco-research-suggests-recycled-concrete-could-be-a-sustainable-way-to-keep-rubble-out-of-landfills/> [accessed 18 March 2021].

[37] See: https://canada.constructconnect.com/joc/news/projects/2020/12/richmond-paves-way-for-recycled-asphalt

[38] See: https://www.vikingrecycling.ca/about-us

Construction

The construction phase of a circular building's life cycle is largely focused on waste prevention onsite, diversion from landfill, and resource management. Key activities include waste minimization, as well as material recycling (i.e., collection, sorting / separation, processing, and transportation). This sub-section on construction focuses on onsite waste diversion and management practices during the construction and renovation stages of a building. Waste prevention as a topic is covered in the circular design and building materials sections whereas, waste diversion is expanded on in the deconstruction and resource recovery sections of this report.

With landfill space at a premium, onsite waste diversion and management is a critical issue for local and regional governments, as well as for industry. Leading Canadian construction firms have developed robust onsite waste management plans and processes are to effectively optimize source separation, material reuse, and recyclability options.

In some provinces and jurisdictions, major real estate developments are expected to more effectively divert and manage construction waste, with a shifting focus of waste as a resource. As one example, Waterfront Toronto is actively looking to revitalize and transform 800 hectares (2,000 acres) of brownfield lands on the waterfront into sustainable, mixed-use communities and dynamic public spaces. Throughout the major development, Waterfront Toronto has set a 50% waste diversion target.

Below is a short-list of Canadian leaders in onsite construction resource and material management as examples:

- **EllisDon** has an environmental policy that takes advantage of local reduction, salvaging, and recycling opportunities by creating a projection—a site-specific waste reduction work plan meeting federal, provincial, and local regulations and taking into consideration green building rating systems. The company's sub-contractors, suppliers, and service providers are also expected to assist with the preparation of the waste projection, keep track and report out against the metrics, and follow the waste reduction plan during construction.
- **Ledcor** is a multi-faceted construction company that offers specialized services in project and construction management. Ledcor is a frequent user of recycled crushed concrete in many of its building construction projects and has been pursuing deconstruction as a practice. Ledcor also a leader in design and adaptive reuse having developed the largest LEED® Platinum Adaptive Re-use project in North America in 2011.[39]
- **Pomerleau** is a leader in lean construction, a project management method used at many of Pomerleau's construction sites in Quebec that is designed to maximize added value through the minimization of all wastes (materials, time, etc.).
- **Naikoon Contracting Ltd.** has developed expertise in digital project delivery and prefabricated mass timber systems. Utilizing building information modelling (BIM), Naikoon executes a "virtual build" prior to starting work on site to minimize errors and waste while speeding up erection and weather protection of its building projects.

Beyond waste minimization and recovery, sharing platforms are an additional circular strategy being applied during the construction and renovation phase of the building life cycle, with organizations offering shared equipment and tools as an example – although many are primarily focused on the residential do-it-yourself (DIY) sector. One example is the Toronto Tool Library, one of 40 tool libraries that have been founded across North America since 2012, which provides its members with various tools and equipment for home maintenance, remodelling, carpentry, plumbing, and electrical work.[40]

[39] See: https://www.ledcor.com/our-projects/building/commercial/green-exchange

[40] See: https://www.torontotoollibrary.com/about-us

Building Use & Operations

The use and operations stage of the building and infrastructure asset life cycle is of critical importance to advancing a more circular built environment in Canada. Enabling this phase requires embracing several circular principles and strategies, including design for durability, design for adaptability, adaptive reuse, as well as extending a building or infrastructure asset's life cycle and usage through regular maintenance, renovation, and repair to ensure they can withstand the test of time. Buildings and infrastructure must also be able to withstand growing pressures exerted from environmental factors such as climate change and extreme weather events.

As referenced earlier, the CSA Group has developed a standard for design for durability (S478:19), which was referenced in the LEED Canada for Durable Building credit (although it was not adopted for LEED v4). Renovations and repurposing buildings can increase the performance of a building over the entire life cycle.

The CSA Group has also developed its guideline for design for disassembly and adaptability (covered in more detail in the next section). To date, design for adaptability considerations in Canada have not been broadly adopted, partly because of a disconnect between the interests of property developers and building owners often not extending the typical lifetime of a building.

However, across Canada, shifting demographics are requiring buildings to be more flexible as communities and their needs change. The concept of flexible spaces also builds on the trend of co-working spaces to unlock the potential of underutilized space in buildings while balancing the risks normally associated with shorter tenures.

Most recently, the impact of the COVID-19 pandemic in Canada is resulting in structural shifts in the demand for commercial office space, as well as retail and warehousing real estate, with more people working from home and many shifting to ecommerce platforms to do their shopping. The City of London, England, for example, has witnessed increased demand for flexible commercial office space, in some instances by 114%, in towns on the outskirts of the city centre, also termed "second-tier" cities. An Arcadis survey found that while offices will remain important for fostering collaborative work, their sizes will likely decrease and need to become more flexible.[41] As a result, upgradable buildings that are adaptable to meet changing building functions is becoming an emerging priority for building architects and designers in Canada.

Building owners and property managers are also beginning to develop innovative leasing approaches and models that enable more flexible use of real estate (retail, commercial, and mixed-use properties as examples). Façade leasing is another innovative model that looks at leasing the building envelope components and maintains them over time through long-term service contracts (i.e., product as a service circular strategy) in order to improve energy, cost savings, and GHG emissions performance, as well as an opportunity to recover and repurpose the materials at end of life.

GI Quo Vadis is a leader in construction practices and building property management, is one example of a company that is working to redevelop a building as a technological showcase. Based in Montreal, Quebec, Quo Vadis has repurposed a historical textile industrial facility originally built in 1908 to a dynamic business centre, the Dompark Complex.[42] The building is employing a façade leasing model that has been instrumental at improving the buildings energy performance and reducing its environmental impact.

[41] Federation of Canadian Municipalities, 'Urban Project Framing Report: City-Building, Intensification and COVID-19', 2020 <https://data.fcm.ca/documents/up/urban-project-report-city-building-intensification-COVID-19.pdf> [accessed 8 April 2021].

[42] See: https://giquovadis.com/portfolio/complexe-dompark/

CASE STUDY: UNBUILDERS DECONSTRUCTION

Vancouver-based Unbuilders Deconstruction 'unbuilds' homes and buildings by hand. They operate with solid business models based on circular material flows which benefits them, their extended supply chain, and the environment in general.

As a material wholesaler, Unbuilders supplies artists, designers, and other value-adding actors such as Wood Shop, Life Space, and Western Reclaimed Timber with source material allowing them (among others) to operate viable businesses using reclaimed materials. Unbuilders supplies their sister company Naturally Crafted with high-value materials and items, which sell directly to consumers thereby realizing retail-level profit margins while providing consumers with highly sought-after 'character' materials and forms. Moreover, at clients' requests, reclaimed structural timber is donated to Habitat for Humanity (a registered charity) resulting in client tax receipts potentially into the thousands of dollars. Hence, Unbuilders provides value along several supply chain nodes.

Unbuilders' main challenge is scalability: it is a labour-primary business requiring skilled and semi-skilled workers for every project. More projects = more labourers: there are very few 'economies of scale' to be had so all projects carry high labour costs. Both the wholesale and retail markets for reclaimed materials are relatively small compared to new material markets, and, although this allows for higher per-item price points, it means the total volumes are low. However, as reclaimed materials become more sought after by both structural and interior designers due to their 'character' and distinctiveness, these markets, however small, will continue to thrive.

Credit: Unbuilders

Deconstruction & Resource Recovery

Deconstruction is an emerging trend in Canada as builders shift away from the traditional demolition of buildings, to recover materials from landfill and look at secondary markets for these materials and resources. Deconstruction is also a major job generator, with potentially three to five times the employment created than through traditional demolition.[43]

Construction waste such a wood, cement, concrete, and steel can be separated and reused for future applications. Currently, however, the market demand for recovered materials and resources varies depending on the geographic location in Canada and the material type.

Key drivers behind the movement toward deconstruction and resource recovery in Canada include supply chain and material pricing volatility. While extracting metal for recycling has long been economical, with lumber prices at a three-year high in Canada, there is growing interest in salvaging structural timber. Procurement and lifecyle assessment (LCA) initiatives are also drivers of growth in resource recovery and secondary material utilization in Canada.

In addition, building codes and bylaws across Canada are starting to consider diversion and recycling targets to drive the uptake of more deconstruction over wasteful demolition practices. Metro Vancouver regional government, for example, charges disproportionately higher tipping fees on unsorted CRD waste at its material recovery facilities, thereby incentivising diversion and alternative disposal/reuse models for materials with embedded value. The City of Toronto's Green Standard encourages higher diversion rates based on its Tiered model (see more details in the following 'Enabling Ecosystem' sub-section).

The City of Vancouver has been out in front, however, having introduced a Green Demolition Bylaw back in 2014 that requires 75% of materials from homes built before 1950 one- and two-family homes to be recycled. Pre-1910 and heritage-registered one- and two-family homes require deconstruction.[44] This cohort of homes in this age range represents approximately 70% of all home demolitions in the Greater Vancouver region. The Bylaw is expected to result in diversion of up to 18,000 tons of wood and building material from landfills annually and is both a strong signal to move the construction and demolition sectors towards sustainable innovation, and an enabler of circular business models such as **Unbuilders** (see sidebar). The City of Vancouver has also linked its municipal permitting at the building's end of life (traditional demolition) phase to support resource recovery. This policy can trickle into other circular strategy areas (e.g., adaptive reuse for product use extensions).

Below is a short-list of Canadian leaders in deconstruction and resource recovery as examples. Metro Vancouver has published a useful construction and demolition waste reduction and recycling toolkit that includes a number of additional case studies on resource recovery and deconstruction.[45]

- **Sea to Sky Removal**, a certified B Corporation, hand separates all recyclables from construction sites to maximize diversion, as well as recovers any reusable items.
- **3RMCDQ** is a consortium of companies and stakeholders from all regions of Quebec. They have in common to promote the development of the recovery, recycling, reuse, and reclamation of products. The companies share collection, transport, sorting, recovery, conditioning, recovery, recycling, and reuse of construction products.
- **Nouvel Horizon Saint-Laurent G.P. (NHSL)** is the leading firm responsible for the deconstruction of the Samuel De Champlain bridge, one of the largest and busiest bridges in North America.

[43] *The National Zero Waste Council, an Initiative of Metro Vancouver, Is a Leadership Initiative Bringing Together Governments, Businesses and Non-Government Organizations to Advance Waste Prevention in Canada ACKNOWLEDGEMENTS* <https://www.oregon.gov/deq/mm/Documents/mmFramework2020.pdf> [accessed 26 March 2021].

[44] See: https://vancouver.ca/home-property-development/demolition-permit.aspx

[45] See: http://www.metrovancouver.org/services/solid-waste/SolidWastePublications/DLCToolkit.pdf

- **Priestly Demolition** is one of the most versatile and innovative demolition companies in Canada. Priestly Demolition is recognized for recovering and salvaging assets, including wood beams, steel structures, and plant equipment from demolition project for reuse. They also have custom concrete crushing services that they can recycle and repurpose.
- **Enwave Energy** is a waste hauler and recycler, as well as a waste-to-energy facility operator. Enwave supports PEI by providing their primary method of dealing with CRD waste. PEI uses Enwaves' W2E. on waste wood as a primary fuel, saving cost and CO2 in hauling, 90% landfill diversion.

Reverse Logistics

There are business opportunities to ensuring materials and resources are diverted from landfill and brought back into the supply chain through 'reverse logistics'. Reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value or proper disposal. It is a crucial part of the circular value chain and one of the main differentiators between a traditional value chain and a circular one.

Reverse logistics is the process that enables the circular loop and associated mini loops to be closed. Managing the return and recovery of products and materials from businesses, deconstruction sites, and material recovery facilities back into the value chain is a key tenet of the circular economy that enables products materials to be recycled, reused, and remanufactured.

Existing waste haulers and recyclers in Canada (firms such as Waste Management, GFL, and others) are well-positioned to enable secondary markets and support more reverse logistics should market demand for recovered materials grow.

Credit: Unbuilders

The Enabling Ecosystem

Advancing a circular built environment in Canada will require more than just a coordinated approach amongst the direct supply chain stakeholders across the building and infrastructure asset life cycle. It will only succeed through collaboration with the broader ecosystem, in particular governments and regulators at all levels, educational institutions, research agencies and academic think-tanks, industry associations, labour unions, non-profits, standards bodies, and financial institutions.

Enabling ecosystem actors foster cross-industry and sector-wide collaboration, as well as provide platforms for sharing and exchanging information, knowledge, and best practice. Engagement with local actors, training, education, and ongoing engagement between the building's life have all helped to drive development in the circular economy in Canada. Opportunities to learn from, and share, experiences can accelerate the industry transition.

Government & Regulators

Policy direction and regulatory measures from leading cities and regional governments in Canada, as well as incentives, have been responsible for driving change on the ground across the built environment sector in order to enable the circular agenda.

At the federal level, the 2020 National Building Code includes provisions for mass timber construction up to 12 storeys. The Government of Canada has also launched its Greening Government Strategy that includes considerations for procurement and real property.[46] All new construction and major retrofits prioritize low-carbon and climate resiliency. A building life cycle cost-benefit analysis is used to inform building decisions. The federal government through Natural Resources Canada (NRCan) has been promoting circular materials and innovation, including through its Green Construction through Wood program which encourages the greater use of wood in construction projects and supports Canada's transition to a low-carbon economy.[47] In addition, the National Resource Council (NRC) is creating a life cycle inventory database for Canada, referred to as LCI2 (to be launched in 2023), along with guidance documents for how LCA should be conducted in Canada.

Provincial governments have been important for supporting circularity in the built environment, including through extended producer responsibility (EPR) measures, bans on certain products from landfill, and for various wood first policy initiatives. The provinces have also been collaborating with Environment and Climate Change Canada through the Canadian Council for Ministers of the Environment (CCME), having published a guide in 2019 for identifying, evaluating, and selecting policies for influencing CRD waste management, including considerations for circular economy principles.[48]

In 2009, the B.C. Government amended its building code to allow six-story (mid-rise), wood-frame residential construction. In the twelve years since Wood First was introduced in B.C., the use of wood in building construction has grown rapidly, particularly in the multi-storey residential market and in institutional and recreational buildings. More recently, B.C. launched its Office of Mass Timber Implementation (OMTI) within the Ministry of Jobs, Economic Recovery, and Innovation, to lead the expansion and use of mass timber in B.C. buildings.

In Quebec, la Charte du Bois du Québec's (the Quebec Wood Charter) objective is to increase wood use in the building sector and to decrease GHG emissions associated with this sector. The Charter also aims for developing wood products with high-value added. The Charter is administered by the Ministère des Forêts, de la Faune et des Parcs.[49]

[46] See: https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html

[47] See: https://www.nrcan.gc.ca/science-data/funding-partnerships/funding-opportunities/forest-sector-funding-programs/green-construction-through-wood-gcwood-program/20046

[48] See: https://www.ccme.ca/en/res/crdguidance-secured.pdf

[49] *Promoting Sustainable Building Materials and the Implications on the Use of Wood in Buildings A Review of Leading Public Policies in Europe and North America*.

At the local government level, examples of leaders in Canada include:

- The **City of Vancouver**'s Zero Waste 2040 Strategy has a circular economy lens applied and includes construction waste as a key focus area, supported by its Green Demolition Bylaw described earlier in this report.[50]
- The **City of Victoria** recently launched its Zero Waste Victoria strategy that has Construction and the Built Environment as one of five key pillars. Short-term actions include a focus on demolition material salvage.[51]
- The **City of Toronto** has been largely focused to date on home renovation waste and bans on some materials.[52] However, the Toronto Green Standard includes targets for CRD material diversion, including 75% for Tier 2 and 90% diversion for Tier 3, which has been encouraging salvage and reuse locally. Its version 4 has also been taking into consideration embodied carbon.[53]
- The **City of Montreal** is currently developing a Circular Economy roadmap with CRD waste as a key focus. The roadmap is not yet released in the public domain.
- **Lunenburg County** became the first jurisdiction in Nova Scotia to create a waste management system that required waste to be source separated into 3 distinct streams. They opened the first centralized commercial scale composting facility in North America. Lunenburg's system was influential in determining how the province's municipal solid waste should be managed, focusing on maximizing the recovery of materials from waste.[54]

The City of Vancouver's economic development agency, the Vancouver Economic Commission, has also been championing various circular economy initiatives as it relates to the built environment, including a study on the business case for deconstruction and its economic potential, in partnership with BCIT and Unbuilders.[55]

Post-Secondary Education, Training & Research Institutions

Post-secondary education and research institutions across Canada have been actively involved in both applied research and relevant training. Below are just a few leading examples from across Canada:

- **BC Institute of Technology (BICT)'s** School of Construction and the Environment is supporting circular practices in construction through its programs, as well as leading work on embodied carbon and consumption-based GHG emissions and material flows through its Centre for Ecocities.
- **The Wood Innovation Research Laboratory (WIRL)** at the **University of North British Columbia (UNBC)** is a state-of-the-art wood science and engineering research facility in Prince George that provides students, faculty members, and researchers from UNBC's Master of Engineering in Integrated Wood Design program with the ability to build and test large-scale integrated wood structures using engineered wood products such as Cross-Laminated Timber, Glued Laminated Timber, and Laminated Veneer Lumber.[56]
- **University of Toronto's Mass Timber Institute** aims to position Canada as a global leader in sustainable mass timber research, education, development, and export by leveraging relationships between educators, researchers, industry, and Indigenous groups across Canada and internationally.

[50] See: https://vancouver.ca/green-vancouver/zero-waste-priorities-and-background.aspx
[51] See: https://www.victoria.ca/EN/main/residents/climate-change/waste-reduction.html
[52] See pages 50-51: https://www.toronto.ca/wp-content/uploads/2017/10/9803-Final-Long-Term-Waste-Management-Strategy.pdf
[53] See: https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-overview/
[54] *Waste Management Practices: Literature Review*, 2011.
[55] See: https://www.vancouvereconomic.com/research/the-business-case-for-deconstruction/
[56] See: https://www2.unbc.ca/engineering/wood-innovation-research-laboratory

- **CIEREC Center at École de technologie supérieure (ÉTS)** is establishing a living lab for circular construction and deconstruction, a first of its kind in Quebec. The living lab will include stakeholders from across the value chain (i.e., manufacturers, distributors, architects, builders, and researchers) with a focus on DfD/A, low-carbon materials innovation, modular construction, and deconstruction.
- The **Canadian Industrial Research Chair on Eco-responsible Wood Construction (CIRCERB)** at **Laval University** is a multidisciplinary and integrated academic platform, partnered to an industry consortium, whose efforts cover the entire construction value creation network, in order to develop eco-responsible solutions, using wood-based materials to reduce the ecological footprint of buildings.[57]
- **Universite de Montreal** has an architecture school doing applied research on circularity in the built environment.

Industry Associations & Not-for-Profits

Industry associations and non-profits play an important role in supporting collaboration and awareness building for the circular built environment in Canada. Below are a few leading examples from across Canada:

- **National Zero Waste Council** has several initiatives that support the circular built environment, including a core focus on deconstruction over demolition, efforts to improve the business case for recycled asphalt, and a CRD Working Group which is focused on assessing the opportunities to enhance waste prevention and promoting circular economy principles within the construction and built environment sector.[58] The CRD Working Group is made up of industry professionals and government representatives across Canada.
- **Canadian Construction Association (CCA)** helps to lead industry on adopting best practices. The CCA is the host of Canadian Design-Build Institute and the Lean Construction Institute of Canada.
- **Canadian Home Builders' Association (CHBA),** represents the residential construction industry with committees and councils in the home renovation space, net zero energy, modular construction and the urban council.
- **Royal Architectural Institute of Canada (RAIC)** is a not-for-profit, national organization that has represented architects and architecture for over 100 years. RAIC promote excellence in the built environment and to advocate for responsible architecture and circular design practices.
- **Canada Green Building Council (CaGBC)** has been working since 2002 to advance green building and sustainable community development practices in Canada. The CaGBC is the Canadian license holder for the LEED Green Building Rating System and supports the WELL Building Standard in Canada.
- **Building Owners & Managers Association (BOMA)** represents the Canadian commercial real estate industry and supports the sector in various ways, including the connectivity between industry leadership and the built environment.
- **Smart Prosperity Institute** has been conducting research on the circular economy as applied to various industrial sectors, including construction.
- The **Carbon Leadership Forum** has founded the embodied carbon network which is advancing a stream of work in North America that aligns with circular materials and practices.
- **FPInnovations** is a private not-for-profit organization that specializes in the creation of solutions in support of the Canadian forest sector's global competitiveness. Efforts include research on forest bioproducts, LCA, environmental EPDs, as well as construction materials and process innovation. etc. Also interested in buildings and novel bioproducts such as biofuels and biochemicals.
- **CIRAIG** is the International Reference Center for Life Cycle of Products, Services, and Systems (CIRAIG) and is the leading research group and center of expertise on sustainability and life cycle

[57] See: https://circerb.chaire.ulaval.ca/a-propos/eng/

[58] See: http://www.nzwc.ca/focus-areas/construction/what-we-are-doing/Pages/default.aspx

analysis (LCA) thinking in Canada.[59] It is also one of the largest internationally.

- **Athena Sustainable Materials Institute** is a non-profit research collaborative bringing life cycle assessment to the construction sector. Life cycle assessment (LCA) is the science behind environmental foot-printing.[60] The Athena Institute works with sustainability leaders in product manufacturing, building design, construction, and green labelling programs to enable smaller footprints in the production and consumption of construction materials.

Collaborative Platforms

System enablers such as product as a service and sharing platforms help keep resources in the system for longer. These include both traditional services associated with manufacturing, such as construction, repair, or maintenance services, as well as entirely new types of services, often enabled by digital innovation, such as co-access mechanisms or models focused on selling a service related to a product—e.g., leasing or repair services—rather than the product itself. Furthermore, in a circular economy, the emphasis is placed upstream to design out inefficiencies and waste throughout product value chains and life cycles. This involves an increasing use of services—a trend that the post-COVID-19 recovery may help accelerate. [61]

Many of the sharing platforms leverage social networks, which has the effect of increasing transparency and consumers' ability to advocate for responsible products, business practices, and affordability. Tool and equipment sharing, leasing, and renting are becoming more common. Tool libraries such as the Toronto Tool Library referenced earlier, are enabling people access to items they would not otherwise have access to, enabling project affordability.[62]

Additional examples of some of these platforms designed to support the built environment and construction sector in Canada include:

- **Ontario Materials Marketplace** is a material sharing platform that was developed by the Council of the Great Lakes Region.[63]
- **BizBiz Share** is a resource and online materials marketplace that includes a new focus on the construction sector.[64]

[59] See: https://ciraig.org/
[60] See: http://www.athenasmi.org/
[61] Saara Tamminen and others, *Trading Services for a Circular Economy Ministry for Foreign Affairs of Finland*, 2020 <www.sitra.fi/en> [accessed 23 March 2021].
[62] Margherita Finamore, *Circular Economy in the Built Environment*.
[63] See: https://ontario.materialsmarketplace.org/?locale=en
[64] See: https://bizbizshare.com/

Case Study: Industrial Symbiosis at Valoris Eco-Industrial Park

The Valoris Eco-Industrial Park exemplifies the Industrial Symbiosis model where materials formerly considered waste have found new uses cases, new value, and new opportunities. The Eco-Industrial Park has created fertile conditions for business innovation, research and development, and collaboration between agencies and related industries.

In 1998, GSI Environmental opened a facility at Valoris to provide services for integrated management of biomass, and in 2005 the ELS and participating MRCs began operating a sorting and conditioning bioreactor test centre with GSI. This spawned the opening of a Regional Ecocentre at the ELS to further enhance materials sorting, prioritization, and recovery. From 2013 to today, all of Sherbrook's and HSF's MSW has been taken to Valoris, providing a stable stream of recoverable materials for industrial inputs.

Valoris is a contracted waste hauler with a fleet of trucks servicing the Sherbrook and surrounding municipalities. Hence, part of the business model is for-profit waste removal and management service at various levels: from curbside residential pick-up to CRD waste from contractors and developers and everything in between. On the recovery/disposal end, several companies have been working on technologies, processes, and services to not only recover materials but create new use cases and value-added products.

Biomass created from feedstocks of wood (CRD and household), as well as and forestry waste, dominates the 'types' of technologies in play at Valoris. This is a sector of considerable importance and focuses in Quebec, with various ministries, industry associations, and funding agencies all supporting and developing the sector. The Quebec Ministry of Economy and Innovation, the Centre of Excellence for the Valorization of Residual Materials, and the Centre of Excellence in Clean Technologies are all direct participants in Valoris, helping to create an ecosystem of support, funding, technology transfer, and R&D to keep advancing the sector.

Metric Modular, courtesy naturallywood.com

5. Key Barriers & Enablers for the Circular Built Environment

Barriers

There are multiple structural and systemic barriers that must be addressed to improve the business case for investing in circular strategies in Canada's construction, real estate, and built environment sector. The barriers are described below.

- **Cost challenges of transition to a more circular built environment versus the linear status quo.** The current linear system does not assess the real costs of consumption (they are currently externalities borne by society). Many developers, the design community, and construction firms do not maintain responsibility for their buildings and related materials at end of life and are, therefore, not incentivized to consider their environmental impact. Furthermore, the extraction and use of virgin materials / resources is often subsidized and/or cost less than secondary, recycled materials. The benefits of minimizing waste during construction and operations do not necessarily accrue to those paying the costs, creating disincentives to change. For example, builders' factor into their tender price the waste that will be generated during construction, and frequently they allow for waste if it means speeding up the schedule (particularly common with drywall).
- **Lack of awareness / information and standardized definitions**. There is a broad lack of awareness and understanding of the circular economy as it relates to the built environment and its opportunities and benefits for communities and the private sector. Where awareness and understanding exist, the focus remains largely on waste management and recycling rather than harnessing the full value through design, material and process innovation, and new circular strategies such as leasing models. Furthermore, the lack of standardized definitions, information, and data (such as on material flows) creates challenges for local, regional, and cross-border collaboration.
- **Fragmentation across construction industries and sectors.** The industry and its ecosystem are often fragment and operates in silos (and frequently at odds with each other) across the value chain (often based on service or function within the buildings life cycle), which creates barriers for the collaboration and systems approach required to advance circularity.
- **Misaligned policies, incentives, and market signals.** Current policy, legal, and regulatory frameworks, as well as incentives for circular building design and development, are not well-aligned with circular economy principles at present. Inconsistent policy and regulatory frameworks between jurisdictions create challenges for business and investment risk. Cities also lack jurisdictional control over much of the construction waste stream, creating additional challenges to regulating change. Access to capital to commercialize and scale up circular economy solutions is often lacking. Furthermore, there are often conflicting market signals, with the interests of short-term investors misaligned with the long-term investment required for the circular economy transition (i.e., investors are often not concerned with the full life cycle of a building or what happens at end-of-life).
- **Infrastructure gaps and supply chain issues.** The construction supply chain is complex and differs by geographic region, creating structural barriers to the changes required for circularity. Ensuring material and feedstock quality, reliability, and affordability within circular supply chains is a challenge for innovation and investment and can also create legal and intellectual property issues. The market for recycled materials is often regional, creating challenges for cross-border material flow and jurisdictional control – existing trade frameworks and policies can create further issues. Furthermore, the market demand in Canada for reclaimed materials is limited at present, which limits the investment in new infrastructure and activities such as material marketplaces and reverse logistics.

Enablers

A number of key enablers that can support the circular built environment transition in Canada are outlined below.

1. **Embracing Circularity in the Design Stage.** The most significant opportunity, for increasing circularity is at the design stage for both materials and whole structures. As planning for circularity is a radical departure from traditional practice, systems thinking for circularity is an essential approach that requires industry collaboration. Systems thinking for circularity can be applied broadly to both product and service applications.[65] By incorporating systems thinking for circularity into value chains, companies and other key stakeholders can innovate and create solutions focused on displacing linear solutions.
2. **Education and Awareness.** To unlock the circular economy, stakeholders throughout the value chain require more education and awareness to shift from prevailing mindsets and business-as-usual approaches. Designers and developers must consider the whole life cycle of an asset, from how it will perform throughout its service life, to how it can be taken apart and its component parts recovered and reintegrated into the supply chain. Similarly, operators of buildings and infrastructure must understand how approaches in leasing can support more flexible and adaptive use and reuse.
3. **Cross-sector Collaboration.** Collaboration across the value chain is essential to implementing circular economy initatives. Given the structural change to value chains associated with integrating circularity, it is important for stakeholders to understand the needs and constraints of other value chain actors to design viable and effective solutions. Changing conditions also introduce risk into the building process. Collaborating with other value chain actors can distribute the financial risk across a broader array of stakeholders to reduce potential risk to any single party.
4. **Supportive Policy, Incentives, Procurement, and Regulation.** While the private sector can play an important role in enhancing circular economy in the built environment, government can also drive the transition through policy and regulatory approaches, incentives, and fiscal measures, as well as through public and industry procurement. Governments can introduce regulation on materials management, construction practices, and asset management to support circular economy objectives. Incentives and fiscal policies available to governments include increased landfill fees, taxes on virgin materials, grants that support innovation and new business model adoption, and undertaking capacity building programs to support re-skilling labour.
5. **Business Model, Process, Supply Chain, and Technology Innovation.** Innovation in all of its applications (business model, process, supply chain, technological, social) is a key driver for the circular economy – which is no different for the built environment and construction sector. Innovation can address cost issues and improve productivity, while technology and digital solutions can support better information sharing and tracking of resource and material flows.

[65] See https://hbr.org/2018/09/why-design-thinking-works

6. Accelerating the Circular Built Environment in Canada

There is a significant economic opportunity for Canada to rethink how buildings are designed, managed, maintained, as well as how construction materials and resources can be more effectively recovered and brought back into the supply chain at end of life to eliminate waste in all of its forms (described in Section 3 of this report). This, in turn, has the potential to provide additional economic, social, and environment benefits (including GHG emission reductions).

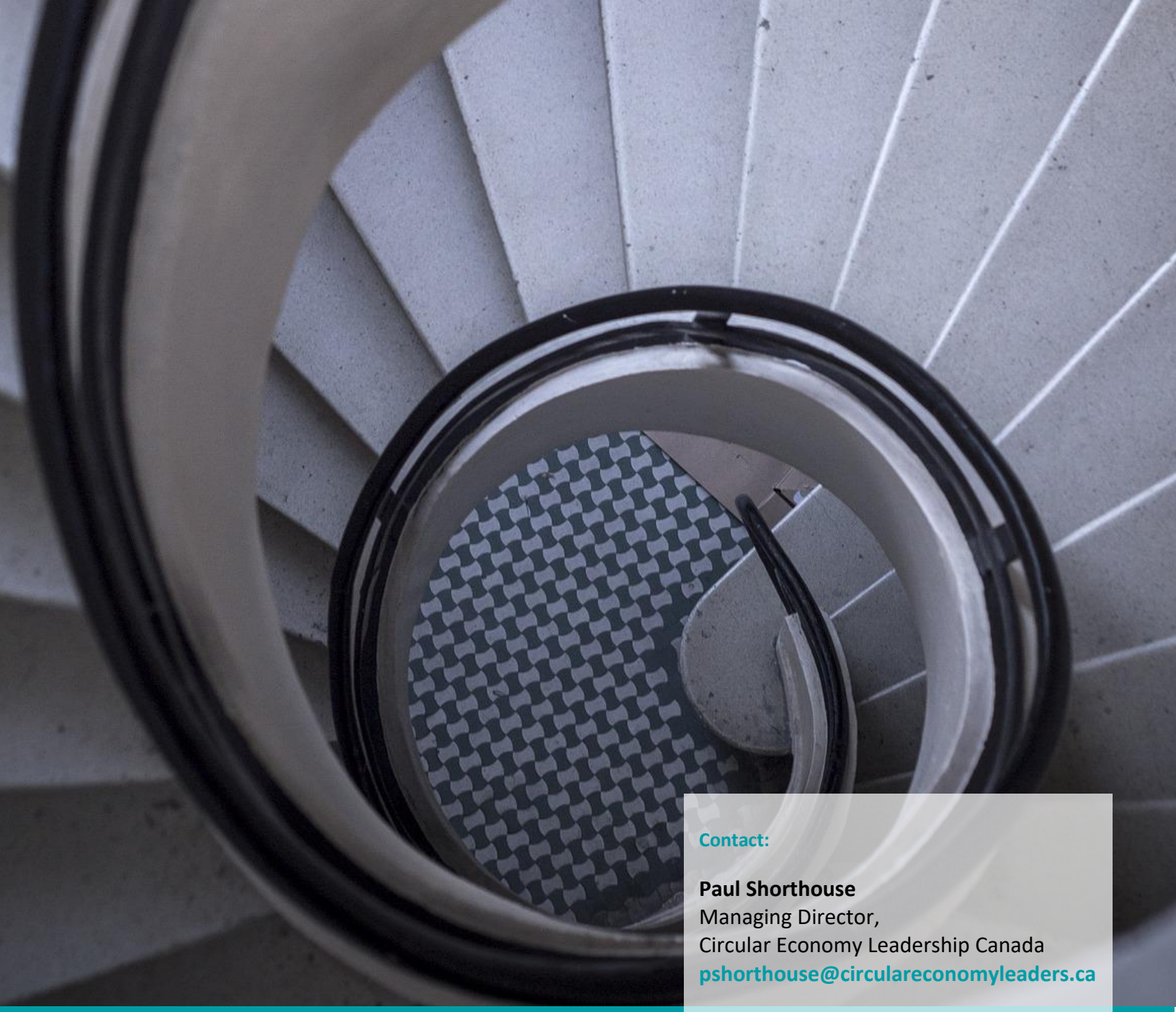
Several underlying enablers have been identified that can help address the barriers outlined in the previous section – which must be considered as part of an interconnected system for maximum benefit and returns. Creating a collaborative industry culture focused on disseminating knowledge and information across the value chain and between parties engaged in the building process will increase overall confidence in the viability of these circular strategies, methods, and practices.

Summary of Recommendations

The recommendations described below summarize key considerations for advancing circularity in Canada's built environment sector.

Focus Area	Recommendations
Embracing Circularity in the Design Stage	• Since a significant opportunity for increasing circularity exists at the design stage for both materials and whole structures, there is a need to develop targeted training and education for architects and engineers on designing for circularity. • Certification programs, such as LEED, can consider expanding their point systems beyond their current levels to further incentivize circular design best practices (e.g., DfD/A, durability, deconstruction).
Education and Awareness	• Demonstrate the business case for the circular built environment through case studies, resource toolkits for industry, and knowledge sharing. • Integrate circular principles into post-secondary education and trades training programs in Canada. Government, post-secondary institutions, professional associations, and training program administrators can play leadership roles by developing and supporting programs that train building professionals in circular design and construction principles and practices.
Cross-sector Collaboration	• Enhance relationships between building suppliers and architects to increase shared responsibilities over material use, increase demand for secondary materials, and circular building designs by breaking down silos in the sector. • Support Integrated Design Processes and Integrated Project Delivery approaches with circular built environment principles. • Advance industrial symbiosis models to support secondary materials.

Supportive Policy, Incentives, Procurement, and Regulation	• Enhance CRD sector diversion through expanded EPR and landfill bans. • Harmonize regulatory approaches to drive circular practices in the built environment sector, including local government bylaws to drive more deconstruction practices in Canada. • Embed standards for disassembly, adaptability, durability, and deconstruction into building code and local bylaws. • Develop long-term policies that encourage the scaling of circular solutions, including through procurement practices, to drive the market demand for recovered and recycled materials and resources. The public sector can support circular procurement through its own building initiatives and practices (e.g., to drive demand for products such as mass timber and recycled concrete). • Transition to more performance-based practices and standards that encourage building flexibility and adaptive reuse approaches. • Undertake audits and develop inventories of salvaged materials in public and private-sector building projects in support of the deconstruction industry and secondary material markets.
Business Model, Process, Supply Chain, and Technology Innovation	• Support the adoption of digital innovation in areas such as BIM, building as material banks, and material passports to improve information and decision-making. • Develop an innovation fund to support circular business models, as well as supply chain and technology innovation, focused on addressing circular economy challenges in the built environment sector. • Develop grants to support R&D and innovation into low-carbon and circular building products and materials. (e.g., better understand the GHG emission impact of the life cycle of construction products and materials and how to minimize the embodied carbon and optimize the carbon sequestration potential through cascading resource considerations).



Contact:

Paul Shorthouse
Managing Director,
Circular Economy Leadership Canada
pshorthouse@circulareconomyleaders.ca

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