BACKGROUND MATERIALS FOR CIRCULAR ECONOMY SECTORAL ROADMAPS

CONSTRUCTION

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Smart Prosperity Institute

About Smart Prosperity Institute

Smart Prosperity Institute is a national research network and policy think tank based at the University of Ottawa. We deliver world-class research and work with public and private partners – all to advance practical policies and market solutions for a stronger, cleaner economy.
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ABOUT THE CIRCULAR ECONOMY GLOBAL SECTOR BEST PRACTICES

This publication series aims to provide a starting point in the journey towards a circular economy. These materials are intended to be used as a background resource and rich reference source for future efforts to engage Canadian firms and innovators in this transition, and to build sector-based roadmaps to a circular economy in Canada.

Twelve core strategies for *rethinking* resource consumption and *optimizing* the use of resources to transition to a circular economy are detailed in the Introduction to the series. Real-world practices supporting these strategies are being catalogued for seven sectors, each profiled in its own document:

1. Minerals and Metals
2. Electronics
3. Agri-food
4. Construction
5. Plastics
6. Bio-economy
7. Automotive

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CONSTRUCTION

4.1. Introduction to Construction

The *Circular Economy Global Sector Best Practices* series aims to provide a starting point, background resource, and rich reference source for future efforts to engage Canadian firms and innovators in the journey towards a circular economy, and to build sector-based roadmaps to a circular economy in Canada.

This report profiles the construction sector. It begins with an outline of the economic and environmental importance of the sector, including data on economic potential of waste resources where available. It then profiles the existing circular practices that were identified in the sector, organized according to a common framework for circular economy approaches and strategies developed in 2018 by L'Institut EDDEC in collaboration with RECYC-QUÉBEC, and described in the Introduction to the series. This profile begins with a high-level summary of the circular practices found in each sector, and snapshots of these practices in application, and then moves on to list applied, real world examples for each of these strategies and practices. It provides a list of additional resources for researchers, practitioners, and policy-makers, as well as selected global public policies, and an annotated bibliography of key reports specific to circularity for construction.

4.2. Background

With the world's urban population growing by 200,000 people per day, there is a significant need for infrastructure development.[1] An anticipated 230 billion square meters of new construction will be built within the next 40 years—doubling current global floor area. That is the equivalent of adding the built area of Paris to the planet every week.[2] To do this, investment in infrastructure is projected at C$4.9 billion per year until 2040.[3] Around 20% of this total global infrastructure investment will be in Canada and the United States.[4]

It is estimated that Canada will need to invest over C$1.6 trillion in infrastructure between 2016 and 2040, which is 2% higher than projected infrastructure spending.[5] The construction sector is an important part of Canada's economy. It generates nearly 7% of the country's GDP and employs approximately 7.5% of the workforce.[6]

Globally, the engineering and construction sector is the largest consumer of raw materials and other resources. It consumes 3 billion tonnes of raw materials, and around 50% of steel produced globally.[7] In 2018, the buildings and construction sector represented 36% of final energy use and 39% of energy

and process-related CO_2 emissions.[8] While the building sector's energy intensity—its energy use per square meter—has been decreasing by 1.5% per year on average, this rate is outpaced by growing energy demand and growing total global floor area, resulting in the total CO_2 emissions from buildings growing by about 1% annually since 2010.[9] In Canada, buildings represent 12% of greenhouse gas emissions.[10]

Building construction and demolition represents about one-third of global material consumption and waste production.[11] Further, an estimated 40% of solid waste in urban waste streams comes from construction and demolition waste.[12] However, only 20–30% of this waste is recycled or reused.[13] In Europe, for example, 54% is landfilled.[14] With such a high rate of resource use, there are many opportunities for the construction sector to employ circular economy practices to lessen their environmental impacts.

Even though the construction sector is seen as a traditional industry, in the past few years innovative technologies and techniques have demonstrated the sector's potential to reduce its environmental impact, with concurrent economic and social benefits. For instance, processing recycled construction aggregates generates 40-70% fewer CO_2 emissions than processing virgin aggregates.[15]

Recognising this opportunity, the real estate market has started investing in green buildings, spending nearly C$185 billion globally in 2018 on energy-efficient products and services for buildings.[16] In Canada, construction costs for net-zero energy buildings have dropped 40% in the past decade and estimated operating costs for a net-zero energy ready house — a residence with such a low energy requirement it could rely upon its own renewable energy production — is 30 to 55 % less than for a typical house.[17] Given the economic incentive, the adoption of green building practices in Canada has been largely voluntary. In 2014, 22% of new commercial buildings and 30% of new institutional buildings in Canada were LEED-certified,[18] and this number has grown since.

These practices have made a positive impact on investment, revenue creation, and job creation throughout buildings' lifecycles and value chains.[19] In 2014 alone, Canada's green building sector generated $23.45 billion in GDP and created nearly 300,000 direct jobs, employing more people than the oil and gas extraction, mining, and forestry industries combined.[20]

4.3. Overview of Circular Economy Practices in the Construction Sector

Construction companies have begun to invest in researching and implementing circular solutions. These investments are being made to help address the sector's challenges of reducing resource consumption and waste, increasing energy efficiency, and recovering valuable construction materials. Figure 4-1 summarizes the specific practices employed in the construction sector, organized according to the four objectives for a circular economy and twelve core supporting strategies described in the Introduction to this publication series. Some of these are highlighted below. This is followed by a listing of applied examples of these strategies and practices, with hyperlinks to additional information. Canadian examples are denoted by a red superscript (CDN).

Figure 4-1. Circular economy objectives, strategies, and practices found in the construction sector

Intensified product use

- **Sharing economy**
  - Labour sharing
  - Asset sharing
- **Short-term renting**
  - Equipment rental

Extending life of products and components

- **Maintenance and repair**
  - Proactive maintenance
  - Reverse logistics
  - Climate change adaptation & resilience
- **Donating and reselling**
  - Donating unused assets
  - Exchange of unused materials
  - Cross-industry collaboration and sector networks
- **Refurbishing**
  - Flexible building core
  - Adaptive reuse of existing buildings (land conservation)

Giving resources new life

- **Performance economy**
  - Design build finance operate maintain (DBFOM) projects
  - Product as a service
- **Industrial ecology**
  - Materials made from materials recycled from other industries
- **Recycling and composting**
  - Designing out waste
  - Use of biodegradable materials
  - Construction waste management
  - Energy efficient deconstruction and recycling
- **Energy recovery**
  - Construction waste as fuel

Objectives, Strategies, and Practices

Given the scale of raw material input in the construction sector, many green practices in this sector focus on **REDUCED** resource consumption, with **ecodesign** being a key strategy to achieve this. **Designing buildings for disassembly** is an effective practice as it allows the individual components of these buildings to be easily reused when the buildings are dismantled, acting as an alternative to demolition and landfilling. Another application of ecodesign involves **sustainably sourcing resources.**

Examples of this include opting for wood over steel or concrete and research to design concrete that emits less carbon dioxide through its production. **Process optimization** approaches include the practice of **just-in-time construction**, where materials are ordered and received on an as-needed basis, and the use of **modular and prefabricated buildings**, which can reduce waste by optimizing material efficiency and minimizing waste through factory construction, eliminating on-site resizing and cut-offs. **Responsible consumption and procurement** can reduce transportation time among other things. For instance, homes slated for deconstruction can be put through the unbuilding process in which materials present in the buildings are carefully removed for future use.

Other practices in this sector look to **OPTIMIZE** resource use through the **intensified use of products**. Fostering the **sharing economy** is one way to do this, which can be implemented by sharing tools, materials, information and various other assets. Another way to do this is by offering **short-term renting**. For instance, renting equipment instead of purchasing it encourages better maintenance of the equipment by the manufacturer, thus elongating the product's life. Companies like Dozr offer a platform where construction companies can rent equipment.

Unbuilders: Decontructing homes to recover valuable material

Unbuilders is a Canadian company based in Vancouver that aims to decrease the amount of waste associated with the demolition of buildings and initiate an industry-wide transformation of how the construction industry handles its waste. Instead of demolishing buildings for scrap, Unbuilders deconstructs houses by taking the buildings apart piece by piece. This allows them to maintain the integrity of the materials being removed, ensuring materials can be re-used in future construction projects.

While deconstruction takes more time, effort, and funding than simply demolishing, it has proven to generate several benefits that go beyond creating a second life for the building materials. The first is increased employment. Where a traditional demolition project can be done with one person and a machine, a typical deconstruction process requires six people. If deconstruction were to become a widespread practice across Canada, it is estimated that 75,000 jobs could be created. The second benefit involves creating a profit for the homeowner. By donating reclaimed materials to a charity, Unbuilders' clients receive a tax receipt for the donated goods which can be used to offset the cost of the deconstruction. [21,22]

Extending the life of products and components is another strategy often adopted by the construction sector. Buildings can be specifically designed with **maintenance, repair, and refurbishment** in mind, thus maximizing efficiency when it's time for necessary improvements. Arup, for example, has designed a fully integrated structural health monitoring system in Scotland which has integrated one thousand sensors in a building to give advanced and specific warnings in case of structural problems.

Henk Jonkers has developed a self-healing concrete that contains bacteria that fills cracks in concrete when exposed to water. Yet another strategy is to **donate and resell** unwanted materials, as is being done at Globechain, a platform that matches businesses, charities, and individuals who want to acquire or give away surplus or unwanted stock. Buildings can also be **refurbished** to extend their lives. Baumschlager Eberle Architekten in Austria has developed a blueprint for buildings that can be used for almost any function, such as for habitation, workspace or commercial use, thus limiting their input needs if the function of these rooms should shift. The use of **performance economies** can ensure greater accountability from building manufacturers. Examples include Design Build Finance Operate Maintain Projects, where the organization in charge of the construction and design operates and maintains the structure for a certain period.

Finally, there are many avenues to **give resources new life** in the construction sector. By using material made from **recycled** elements, the construction sector can turn waste produced from other industries into useful construction materials. There have also been some developments in **green insulation**, where insulating materials have been formulated from materials including cork, cellulose from recycled paper, post-consumer textiles like cotton or denim, and feathers from the poultry industry. **Recycling** is another method to give resources new life and is of particular significance for the construction industry given the amount of waste generated by demolitions. The European Commission, for instance, has created a structured plan for the management of construction waste to ensure the maximum amount of reuse and recycling occurs. Construction waste can also be converted into fuel thereby enabling **energy recovery**. For example, the Lafarge cement plant based in Richmond, British Columbia uses refuse from construction sites to power its operations instead of burning fossil fuels.

Arup : Demonstating modern timber construction systems

The Believe in Better building, designed and constructed by Arup in 2014, is the tallest commercial timber structure in the UK. It successfully demonstrates the use of precision engineered modern timber construction systems to achieve a unique workplace in half the normal timeframe.

The building was designed to take advantage of many sustainable practices. Adiabatic cooling and heat recovery provide energy-efficient cooling in the building without using conventional chillers, supplemented by DX coolers which operate at peak temperatures. The building also optimizes performance with its 'shop window' frontage avoiding excessive solar gain because it faces north. Additionally, low flush fittings and rainwater harvesting conserve water resources, employing a flowstow system developed by Arup which saves pump energy and tank space by providing a gravity system with oversized cisterns which store rainwater and serve as a direct source of water for the toilets.[24]

Buildings as Material Banks (BAMB): Mainstreaming the concept of material passports

Buildings as Material Banks (BAMB)[23] is an EU-funded initiative to promote circular economic ideas in the construction industry. Founded in 2015, it has fifteen partners in seven EU nations and has been working to develop a systematic shift in the construction and demolition of buildings. The environmental impact of construction in the EU is significant, as the construction sector represents 40% of greenhouse gas emissions, 45% of the EU's total controlled waste, and uses 50% of extracted resources.

BAMB values buildings not only in what they are currently able to provide, but what they could provide in the future. BAMB views buildings not as static objects with singular purposes, like that of a school or a mall, but as a temporal and dynamic storage of materials that can be easily changed to fit evolving market needs. It is common for demand of buildings use to decline before the natural life cycle of the building has expired. This results in buildings being demolished before necessary, which creates a massive amount of refuse that is often relegated to the landfill. By constructing buildings with BAMB ideas, when this shift in demand occurs the materials that compose the building slated for demolition can be reused and repurposed.

A key concept used by BAMB is the material passport, a novel method to track and save materials used in the building process. This is 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. By keeping track of what materials are being used where, the process of deconstruction is made easier.

Specific Examples: Objective 1, Reduced Resource Consumption

Ecodesign

Design for disassembly

- Caterpillar[25] has been remanufacturing their parts since the 1970s. To do so, they design their heavy construction equipment to be easy to deconstruct, in order to save time and energy during this step.
- Tata Steel[26] in collaboration with Arup has designed steel for reuse recognizing the economic advantage of having components easily separated for reuse or recycle.
- R128 House[27, 28] was designed by architect Werner Sobek, to be dismantlable in end -life and for all parts and materials to be reusable or recyclable. Most elements of the house were built off-site in prefabrication which allowed them to increase efficiency and avoid permanent joining methods that would otherwise make it hard to reuse or recycle.
- Marie Short House[29 30] was designed by Australian architect Glenn Murcutt with elements of adaptation, disassembly and reassembly for mobility.
- The Circular Building [31] was a prototype housing building constructed outside the Building Center for the London Design Festival 2016 by the Built Environment Trust and Arup. It was created to demonstate that components and materials could be recovered and re-used at the end life of the building.

Sustainable resource sourcing

- Cecobois[32 CDN] aims to promote the use of wood for non-residential construction, by being a resource, recognizing excellence and innovation and educating.
- Pomerleau - FondAction Building[33, 34 CDN] built in 2010 was the first commercial building in North America of six floors with a wooden frame (local wood).
- Oskam V/F[35] developed small mobile machines that produce compressed earth blocks. Compressed earth blocks (or rammed earth bricks) don't change the property of the earth, hence it can be reused over and over. It's production needs about 1% of the energy as compared with producing traditional bricks.
- Aerecura Rammed Earth Builders[36 CDN] specializes in rammed earth construction. They also provide energy retrofits for existing construction and sustainable solutions for renovations.
- Arup's Madrid+ Natural Project [37] consists of guidelines to tackle the environmental concerns by proposing simple local solutions. An example of a guideline for material selection is to use permeable surfaces instead of concrete or asphalt (simple technology that improves directly the water absorption).

- Blue Planet[38] has developed a technology that captures CO2 and creates CO2-sequestered aggregate that can then be used in concrete.
- CarbonCure[39] CDN injects CO2 into the concrete, making it stronger.
- Maison du développement durable[40] CDN uses supplemental cementitious materials such as fly ash to lower the amount of cement used; it also features experimental concrete slabs incorporating powdered, recycled glass.
- WaterShed Materials[41] has developed structural blocks with lower carbon footprint than traditional concrete blocks, using half the cement that is usually needed for concrete blocks.
- Covenant University, Nigeria[42] has developed eco-friendly high-strength concrete by replacing a certain amount of sand in concrete with crushed clay bricks.
- University of Oulu[43,44] has developed sustainable cement by using waste mineral wool and geopolymerising it.

Energy efficiency

- Jewson[45] offers a variety of sustainable products that are more energy efficient for building insulation.
- Isover[46] has commercialized complete insulation systems for the best energy saving possible from insulation.
- Glassolutions[47] offers a variety of windows with high performance energy savings.
- Maison du développement durable[48] CDN features a durable green roof with plants carefully chosen plants to help absorb and manage stormwater, reduce the heat island effect, and reduce the building's energy consumption.

Renewable energy

- Arup's SolarLeaf[49] house pilot project built a bio reactive facade onto buildings to generate energy from algae biomass and solar thermal heat. The excess heat from photobioreactors (PBRs) can be used to supply hot water, heat, etc. Carbon to feed the algae can be taken from local combustion processes creating a short carbon cycle.

Designing using Building Information Modeling (BIM)

- BIM[50] is an innovative digital tool that helps optimize buildings; communicate information relating to phases of an asset's lifecycle; and facilitate monitoring and hence preventive maintenance.
- Institute of High Performance Computing[51]developed the Green Building Environmental Simulation Technology (GrBEST) tool by integrating BIM and CFD (Computational Fluid Dynamics) technologies. This software helps architects and engineers model the airflow in residential and non-residential buildings for better and optimized natural ventilation. Using this software, a building in Austria was designed in a way that allows it to self-regulate temperature, humidity level and CO_2 levels, thereby not requiring a mechanical ventilation system.[52]
- BESIX[53, 54] a Belgian entrepreneur did a complete BIM of the Hotel Andermatt, using ,BIMPORTAL.BE[55]. This allowed them to do an accessibility study, simulation of lightning and crowd movement, structural analysis, wind tunnel test and 4D phasing. These simulations helped optimize and create a material passport for the building, giving it an added utility for recycling and recapturing value in the future.

The Ideal

- Construction projects use locally available materials that can be sustainably sourced
- Energy saving materials and construction techniques are developed further and mainstreamed
- More urban buildings are designed and retrofitted with green roofs
- Buildings run on and play a role in the generation of renewable energy
- Construction projects are designed using BIM technologies for disassembly

Process optimization

Prefabricating and modular construction

- Arup[56] developed a method to 3D print structural steel, creating smaller and lighter elements delivering the same function and strength as traditional steel elements. This method can achieve a 40% reduction in overall weight, translating into cost, waste and greenhouse gas emission reductions.
- Pinwheel Structures[57] CDN provides a healthy, comfortable and durable solution for housing construction based on wooden prefabricated panels ("Panelization").

Just-In-Time construction

- BPC CDN used Last Planner System, a software for just-in-time construction for their Tivoli[58] project, which allowed them to reduce waste by ordering (and receiving) materials only as they were needed.

The Ideal

- Prefabricated and modular construction becomes mainstream
- Use of 3D printing in construction reduces waste
- Construction planning is optimized to reduce waste

Responsible consumption and procurement

Reducing transportation footprint

- London's Olympic Stadium[59] used the nearby river to create a canal network to transport materials to the construction site.
- Bau-Val (Bonaventure highway project), [60, 61, 62] CDN the contractor in charge of the demolition of Montreal's old Bonaventure highway and construction of the new ramps at the beginning and end of the highway, reused 95% of the 47 000 tonnes of crushed concrete as aggregates in the backfilling of the new construction. By using materials already on site, they also avoided the transport of waste from the site and transport of new materials to the site.

Deconstuction

- Unbuilders[63] CDN is a Canadian deconstruction company that treats buildings slated for demolition as material banks. Their process of unbuilding involves removing materials with potential for further use from homes, often donating these materials to Habitat for Humanity.

The Ideal

- Construction projects source local materials that reduce transportation requirements
- Construction materials are transported using low-carbon mobility solutions
- Buildings are deconstructed rather than demolished to enable waste recovery

Specific Examples: Objective 2, Intensified Product Use

Sharing economy

Labour Sharing

- Faber Platform[64] CDN allows construction companies to find local workers based on their skills, experience, and availability in Vancouver, BC.

Asset sharing

- Share Peterborough platform[65] is an online service designed to promote asset sharing to increase collaboration between companies in UK's City of Peterborough.
- FLOOW2[66] is a business-to-business sharing marketplace where businesses and organizations can share equipment, personnel, facilities, services, and waste

The Ideal

- Asset sharing platforms for the construction industry proliferate

Short-term renting

Equipment rental

- Dozr[67] [CDN] is a Canadian platform for construction equipment rentals.
- Yard Club Rental[68] [CDN] is an online peer-to-peer service enabling construction professionals to earn income on idle equipment by renting to other contractors, maximizing the utilization.
- Établissement André Cros[69] rents, sells, and manitains specialized equipment for construction.

The Ideal

- Renting platforms for construction industry equipment proliferate

Specific Examples: Objective 3, Extending Life of Products and Components

Maintenance and repair

Proactive maintenance

- Arup[70] developed a fully integrated structural health monitoring system (SHMS) for the Forth Replacement Crossing in Scotland.[71] They equipped it with 1000 sensors to give advance and specific warning in case of structural problems, allowing them to make appropriate inspection and intervention.
- GIATEC[72] makes wireless sensors that are attached to rebars and monitor real-time temperature and strength of the concrete. All the information is sent via their SmartRock Plus app.

Reverse logistics

- Caterpillar[73] uses a deposit return system to ensure that used engines cores are returned, to be remanufactured and resold.

Climate change adaptation & resilience

- Polytechnique Montréal Structural Laboratory[74] is looking into solutions to reduce loss in the built environment after earthquakes. These include neoprene pads for bridges and buckling-restrained braces (BRB) for buildings.
- TU Delft[75] is developing a self-healing concrete. The concrete developed contains bacteria, making it a bioconcrete. The bacteria are dormant in the mix until the concrete cracks and water gets in. When this happens the bacteria germinates to form limestone that closes the cracks.[76]
- Arup Madrid+ Natural guidelines[77] suggest using permeable surfaces like grasscrete to better cope with the more frequent extreme weather events such as sudden intense precipitations.

The Ideal

- New construction is designed with components that can be easily maintained and repaired to prolong its useful life
- Development and proliferation of new technology solutions to monitor the health of structures, so that timely interventions can be made in order to mitigate damage
- New construction is planned to withstand the increasing impact of climate change

Donating and reselling

Donating unused assets

- Globechain[78] is a reuse platform that matches businesses, charities, and individuals who want to acquire or give away unwanted or surplus stock and equipment in the construction, retail and office sectors.

Exchange of unused materials

- Eastex Materials Exchange Program[79] is a free online platform where individuals and organizations can connect to exchange surplus raw materials based on the location.

Cross-industry collaboration and sector networks

- Veolia[80] has partnered with Trakett Group[81], a flooring solution firm. Veolia collects and processes flooring off-cuts from Tarkett's customers in the building industry for reuse in Tarkett's production and manufacturing processes.

The Ideal

- Unused assets and materials from the construction industry are given a new life rather than treated as waste

Refurbishing

Flexible building core

- Falkeis architects[82] designed their Active Energy Building so its rooms can be adapted for different functions. The supporting columns in the building are "Y" shaped and can rotate on themselves to accommodate the need.
- Arup's Derwent London's White Collar Factory[83] in Old Street London was built with a flexible core to enable a switch in its use if necessary.
- London's Olympic Stadium[84] was designed to be transformed after the Olympics for different usages for the community. The Olympic site was transformed into the Queen Elizabeth Olympic Park where housing, schools, health centres, and a business space were integrated. For instance, the Olympic Village was converted into over 2 800 flats, and the Aquatic Center was adapted for community use.

Adaptive reuse of existing building

- Art and Build Architect[85] transformed the Van Volxem building, originally used as an office space, into an apartment.
- Cepezed The Knoop national office[86] project in Utrecht transformed a building that served for decades as headquarters for the Royal Netherlands Army into offices and a meeting centre.

The Ideal

- All usable building structures and components are refurbished for a life that goes beyond their initial function

Performance economy

Design Build Finance Operate Maintain (DBFOM) Projects

- Miller Paving [87 CDN] has developed expertise in realizing projects with DBFOM delivery. Through this project model, they not only design and construct structures, but also operate and maintain them for a certain period.

Product as a service

- Philips[88] offer a "pay per lux" solution to businesses and municipalities by providing lighting equipment on a lease basis, allowing customers to only pay for the lighting service.

The Ideal

- Where possible, performance contracts replace traditional models of construction services

Specific Examples: Objective 4, Giving Resources New Life

Industrial ecology

Green Insulation made from waste

- ThermaCork[89] creates natural insulation from 100% cork, a renewable, recyclable, and biodegradable material.
- Black Mountain[90] uses waste wool from the sheep wool industry to create a natural, non-toxic insulation material.

- Aeropowder[91] uses feathers from the poultry industry to create an environmentally-friendly insulation material.
- Blue Jeans Go Green[92] program collects post-consumer denim to create an insulation product called UltraTouch Denim Insulation.[93]

The Ideal

- New construction materials are developed using waste from other industries

Recycling and composting

Recycling waste

- Veolia[94] worked on a project to upcycle sewage sludge into bio-plastic that can be used as a base layer in road construction.
- British Gypsum[95] offers a take-back and recycling service for plasterboard, helping housebuilders and contractors manage and reduce their waste, reduce costs, and increase savings.
- Second Change[96] is a non-profit that deconstructs buildings and then salvages the usable materials. Those materials are then sold within a certain radius of the retail space.
- London's Olympic Stadium[97] was built using the materials recycled from the derelict buildings demolished on its site.

The Ideal

- Construction and demolition waste is recycled
- Construction projects source and use recycled materials instead of virgin materials

Energy recovery

Construction waste as fuel

- London's Olympic Park[98] uses biomass boilers that use construction waste such as woodchip or other sustainable bio-material as feedstock for the heating and cooling of the site.

The Ideal

- Construction waste is only used for energy recovery if there is no higher and better use

4.4. Additional Resources

The following are additional resources that researchers, practitioners, and policy-makers can draw on to further advance awareness and understanding of opportunities for circularity for Canada's construction sector.

Selected Global Public Policies Supporting Construction Circularity

- *National Carbon Offset Standard for Buildings, Australia (2017)*: A standard developed with the Green Building Council Australia, using known programs such as Green Star and National Australian Built Environment Rating System. It offers frameworks, requirements for carbon neutrality, and a list of best practices. [99]
- *Rwanda Green Building Minimum Compliance building code (2017)*: Dictates that all buildings occupied by 100 or more people in Rwanda are required to comply with the green building certificate policy. [100]
- *Zero Energy Standard, Brazil (2017)*: A certification given to 'self-sufficient energy' buildings, who prioritize energy efficiency and use renewable energy generated on-site or off-site to achieve net-zero carbon emissions annually. [101]
- *Energy Efficiency of Buildings law, Ukraine (2017)*: Mandates that all public buildings must respect specific energy efficiency requirements. [102]
- *Zero Carbon Building Standard, Canada Green Building Council (2017)*: A building performance standard with carbon emissions as the key indicator. [103]
- *Leadership in Energy and Environmental Design (LEED)*: A widely used international green building certification. It includes rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods that aim to help building owners and operators be environmentally responsible and use resources efficiently. [104]
- *Building Research Establishment Environmental Assessment Method (BREEAM)*: An international sustainability assessment method for planning projects, infrastructure, and buildings. It recognizes and reflects the value in higher performing assets across the built environment lifecycle, from new construction to in-use and refurbishment. [105]

Selected Documents on Circular Economy and the Construction Sector

Understanding resource consumption and economic trends in the construction sector

United Nations Environment Programme & International Energy Agency. (2019). *2019 Global Status Report for Buildings and Construction*. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/30950/2019GSR.pdf?sequence=1&isAllowed=y

Finding that buildings generate nearly 40% of global CO2 emissions, this report highlights trends in the construction sector, including widespread under-investment in the energy efficiency of buildings. It finds that significant changes are needed in the way the world's infrastructure is built to meet international climate targets, and with more action the construction industry could reduce its environmental impact. The report gives an overview of key activities to improve the sustainability of the construction sector during this critical window to reduce global emissions.

World Economic Forum. (2016). *Shaping the Future of Construction: A Breakthrough in Mindset and Technology*. Retrieved from http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf

This industry snapshot outlines major trends in the construction industry, its contribution to society and the global economy, and the industry's environmental impacts. It outlines major challenges for the construction sector, such as increasing project complexity and an aging workforce. The report introduces thirty measures to transform the construction industry, including actions that can be taken by the government, although it suggests that the industry as a whole should drive its own transformation.

Strategies and tools for implementing principles of the circular economy in the construction sector

Delphi Group & Canada Green Building Council. (n.d.). *Green Building in Canada: Assessing the Market Impacts & Opportunities: Executive Summary*. Retrieved from https://www.cagbc.org/CAGBC/Advocacy/Green_Building_in_Canada_Assessing_the_Market_Impacts_Opportunities.aspx

This report outlines key trends and drivers of the green building industry in Canada, including a growing focus on retrofitting buildings, shifts in municipal planning, and an overall increasing interest in green building design. It provides an overview of Canada's core strengths in green building, such as building envelope design and engineered wood products, and key strategies for accelerating the green building industry, which include research investment and increased use of sustainable materials. The full report is available only to members of the Canada Green Building Council, but this executive summary provides a useful overview of trends and strategies.

Ellen MacArthur Foundation. (2019). *Designing Buildings for Adaptable Use, Durability, and Positive Impact*. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/2_Buildings_Designing_Mar19.pdf

Though non-exhaustive, this fact sheet presents strategies for incorporating circular economy principles into building design, such as designing buildings with the flexibility to adapt to new uses and taking design inspiration from nature. The report provides case studies and statistics that demonstrate the benefits of more circular design in buildings, including reduced operation costs, reduced resource consumption, and improved living conditions.

Ellen MacArthur Foundation. (2019). *Making Buildings with New Techniques that Eliminate and Support Material Cycles*. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/3_Buildings_Making_Mar19.pdf

This fact sheet presents some construction and manufacturing techniques to implement circular economy principles in building construction and demolition, including selecting locally sourced and renewable materials, and reducing construction time through pre-fabricated materials. Case studies and statistics demonstrate measurable benefits to resource consumption, human health, and environmental impact.

UK Green Building Council & The Crown Estate. (2019). *Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage*. Retrieved from https://www.ukgbc.org/ukgbc-work/circular-economy-guidance-for-construction-clients-how-to-practically-apply-circular-economy-principles-at-the-project-brief-stage/

Created in collaboration with members of the UK Green Building Council, this publication guides construction clients on the practical application of circular economy principles in building construction for non-domestic assets, helping clients and project managers to increase resource efficiency and reduce waste in their projects. It identifies potential challenges that could arise throughout a green building project, such as concerns about compliance with building codes and regulations, and suggests solutions to overcome these challenges.

4.5. Conclusion to Construction

The engineering and construction sector is the globe's largest consumer of raw materials and other resources,[106] and produces an estimated 40% of solid waste in urban waste streams,[107] of which only 20–30% is recycled or reused.[108] With only this small fraction of construction and demolition waste currently recycled and reused, the sector has a long way to go to mainstream circular economy thinking, recapture lost economic value, and reduce its environmental footprint.

Yet this global scan of best circular economy practices in the construction sector reveals that selected firms and operations are already implementing a wide range of practices that support circular economy objectives and strategies, whether or not these practices are explicitly identified as circular. More widesprea d adoption of such strategies and practices will be key to reducing the resource consumption associated with growing demand for new infrastucture, prolonging the life of materials used in existing structures, and recovering valuable construction material during the demolition or deconstruction stage.

In cataloging these examples, our intent is to demonstrate real-world strategies and practices that offer a starting point in the journey towards a circular economy. This information is offered as a background resource and reference source for future efforts to engage Canadian firms and innovators in the journey towards a circular economy, and – ideally – to begin building a Canadian construction sector roadmap to a circular economy.

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