DEVELOPING A CIRCULAR BUILDING MATERIALS SYSTEM AND FOSTERING INNOVATION FROM CONSTRUCTION, DEMOLITION AND RENOVATION (CRD) WASTE

AN ONTARIO-FOCUSED SYSTEMIC POLICY ANALYSIS AND BLUEPRINT FOR CHANGE

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INTRODUCTION

The built environment in Ontario contains a diverse array of structures, spaces, and infrastructure systems designed to support and enhance the lives of its residents. This includes residential and commercial buildings, public amenities such as parks, libraries, and schools, and the vast network of roads, bridges, public transit systems, and utilities that ensure access to clean water, energy, and efficient waste management.

Besides the basic function of offering shelter, there is a growing demand for buildings to provide safety, comfort, accessibility, resilience, health, clean air, and low-carbon pollution; all while the structures form a part of our identity, history, and cultural heritage.

But they also create waste. Lots of waste. This paper is about that.

This research examines why we have so much waste and explores what can be done about it. It investigates a comprehensive understanding of the challenges and opportunities for innovative, underused, or cross-sectoral Ontario provincial policy options that can foster the circular use of Construction, Renovation, and Demolition (CRD) waste and grow the circular built environment.

It combines a literature review of global and local practices, semi-structured interviews with stakeholders across various sectors, and a systemic analysis of provincial waste management policies. Additionally, it leverages information from a participatory design workshop with government officials and industry professionals that utilized generative design and foresight tools to develop innovative policy solutions.

Finally, this paper aims to be solution-oriented and innovative but grounded in today's policy conversation. It aims to support policy-makers and decision-makers by offering a series of policy interventions to transform Ontario's waste management and development practices towards a more circular system.

HOW TO READ THIS DOCUMENT

This document is structured to provide a systemic understanding of the relationship between the construction industry, buildings, waste management practices, and the environmental, economic, and policy factors influencing them.

- The “Executive Summary” offers a high-level overview, capturing key findings and recommendations.
- The “Context” section highlights why Ontario needs systemic change and details the regulatory framework.
- The “Findings” section details the barriers and policy opportunities to shift the market.
- The “Discussion” section explains the choices to settle on the proposed recommendations.
- The “Recommendations” section provides a blueprint for turning CRD waste circular using actionable policies relevant to today’s policy landscape.

Each section is designed to build upon the information presented previously, offering a layered approach to understanding the multifaceted challenges and opportunities within Ontario’s development and waste industries.

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EXECUTIVE SUMMARY

Limited data and diversion

Ontario's construction industry is a significant contributor to the province's economy and its landfills, sending about a million tonnes to the landfill each year (although precise data are lacking). The waste is primarily composed of concrete and aggregates, wood, drywall, asphalt, metals, and plastics, with significant variations in material-specific diversion rates.

Only an estimated 16% of Construction, Renovation, and Demolition (CRD) waste is being recycled or reused in Canada (again accurate data are in short supply), contrasting sharply with an approximate 85% possible diversion rate. This failure to divert underscores a systemic failure in waste management, exacerbated by a lack of precise data in Ontario on the composition and disposal rates of CRD waste.

Big goals, minimal action

In Ontario, the development and waste management sectors are governed by provincial and municipal regulations. Generally, the province sets the framework and municipalities enforce them, however municipalities have limited authority over most Industrial Commercial and Institutional (ICI) waste. ICI waste accounts for 60% or more of Ontario's waste (CRD waste is about 9%). Ontario has set high diversion goals but is failing to meet them, and it is set to run out of landfill space in as early as nine years, which is about the length of time it takes to build a new landfill. Meanwhile, buildings are a major source of carbon pollution, accounting for about a quarter of Ontario's emissions and over 50% in urban centres.

Circular system delivers benefits

A circular built environment emphasizes adapting existing structures, designing adaptable new buildings, and reusing materials, involving architects and builders in selecting circular materials and methods, optimizing operational efficiency, and facilitating material recovery. At the end-of-life phase, buildings are deconstructed, and waste is separated on-site; materials are reclaimed or processed for recycling or remanufacturing into new products and then reused or sold.

Circular practices can significantly reduce carbon emissions and enhance biodiversity while fostering resilient supply chains. Additionally, circularity offers economic benefits by reducing material costs, boosting GDP, and creating new businesses and jobs.

An underdeveloped industry

Ontario's circular CRD waste system faces significant regulatory, economic, operational, and cultural barriers preventing the adoption of circular building practices. Key challenges include the absence of regulations enforcing producer responsibility, insufficient and underdeveloped building standards and codes for circular building practices. These issues are compounded by low-cost bidding procurement practices, complex waste facility approval processes, limited enforcement of existing regulations, and inadequate support for reclaimed or recycled materials. Additionally, rigid municipal rules, slow adoption of embodied carbon requirements, pressures of a housing crisis, and a limited market for reclaimed materials further hinder progress towards a circular waste and materials system. The construction sector also grapples with a skills shortage, low productivity gains, lack of technological adoption, and logistical and cultural barriers that limit the integration of reused materials in building projects.

Interlinked strategic opportunities

There are a number of policies to enhance CRD waste's circularity that would help mitigate barriers, foster new businesses and create jobs. This can be achieved by creating accountability through site-specific waste management plans. Further, there are policies that aim to limit disposal options, align financial incentives through disposal fees and virgin material levies, and improve CRD processes through building codes, green building standards, and support for deconstruction and reclamation infrastructure. Strengthening diversion markets and building capacity at the municipal level and knowledge through industry outreach, benchmarking, and data tracking are also critical. Implementing these policies requires a systemic approach, integrating multiple strategies to reduce and divert and reuse CRD waste effectively.

Focusing on achievable change

In an effort to focus on innovative solutions that are grounded in practical implementation considerations, the final recommendations do not emphasize the wider adoption of Extended Producer Responsibility (EPR). Although EPR is the leading waste management tool in Ontario, it is not recommended because of implementation challenges and limitations. Despite its critical role in facilitating the market adoption of innovative solutions, procurement has been designated as an enabler rather than a leading recommendation due to the challenges in effecting progressive policy change to date.

Instead, the focus is placed on increasing the market value of circular materials through standardization and incentivization to combat economic barriers to materials efficiency and reuse. Further, by supporting reclamation and reuse infrastructure and entrepreneurs will help foster needed supply chains and kick start nascent industries, while breaking down logistical, operational and cultural barriers. Finally, enabling municipal innovation to implement flexible and phased high standards for the built environment will help shift Ontario new and existing building stock, while breaking down regulatory, market and operational barriers.

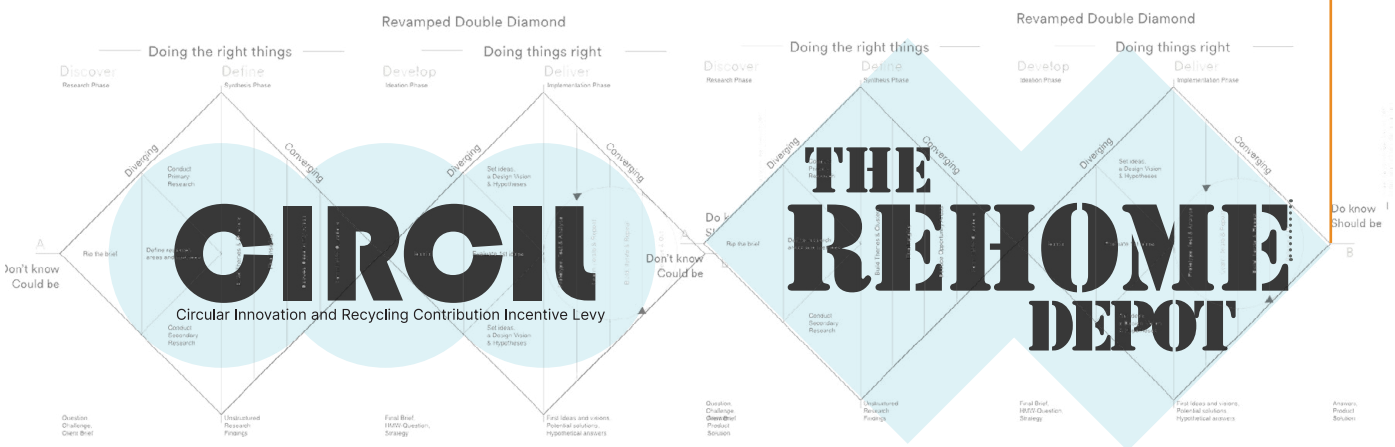
Boosting value, place and leaders

The recommendations aim to tackle a number of interlinked systemic problems by shifting market value, supporting undeveloped circular materials infrastructure, and enabling ground-level innovation.

Levelling the field

Starting in 2026, this study recommends a gradual levy increase on ICI waste, dubbed the Circular Innovation and Recycling Contribution Incentive Levy (CIRCIL). Further, a levy on virgin aggregates and a phased-in landfill ban on clean wood is also recommended to help further foster new businesses and incentivize waste reduction, materials salvage and recycling efforts.

These levies will be revenue-neutral, with all the funds reinvested into the waste management infrastructure to enhance sorting, diversion, and the adoption of new technologies. Additionally, funds will stimulate secondary markets for recycled and reused materials.

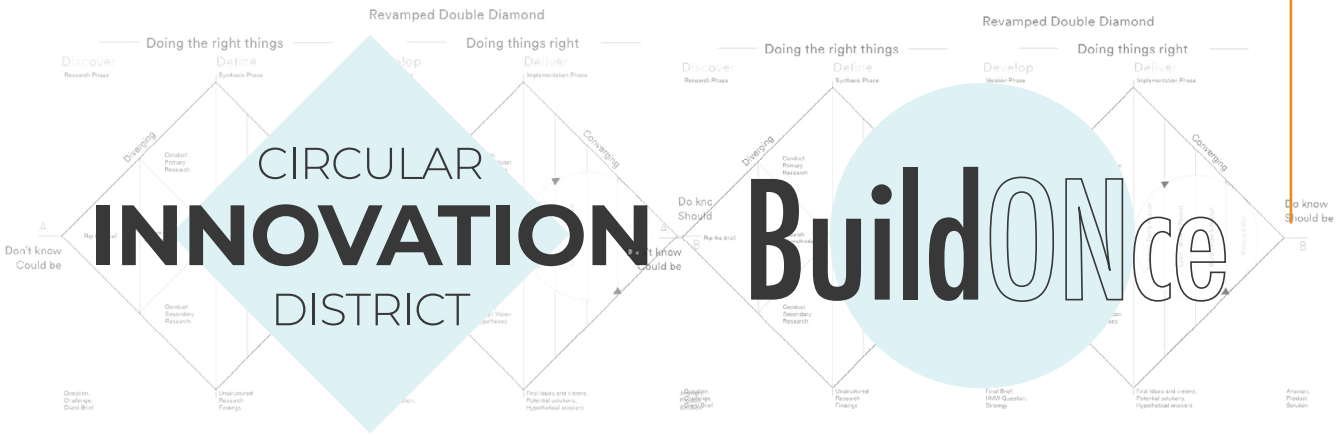


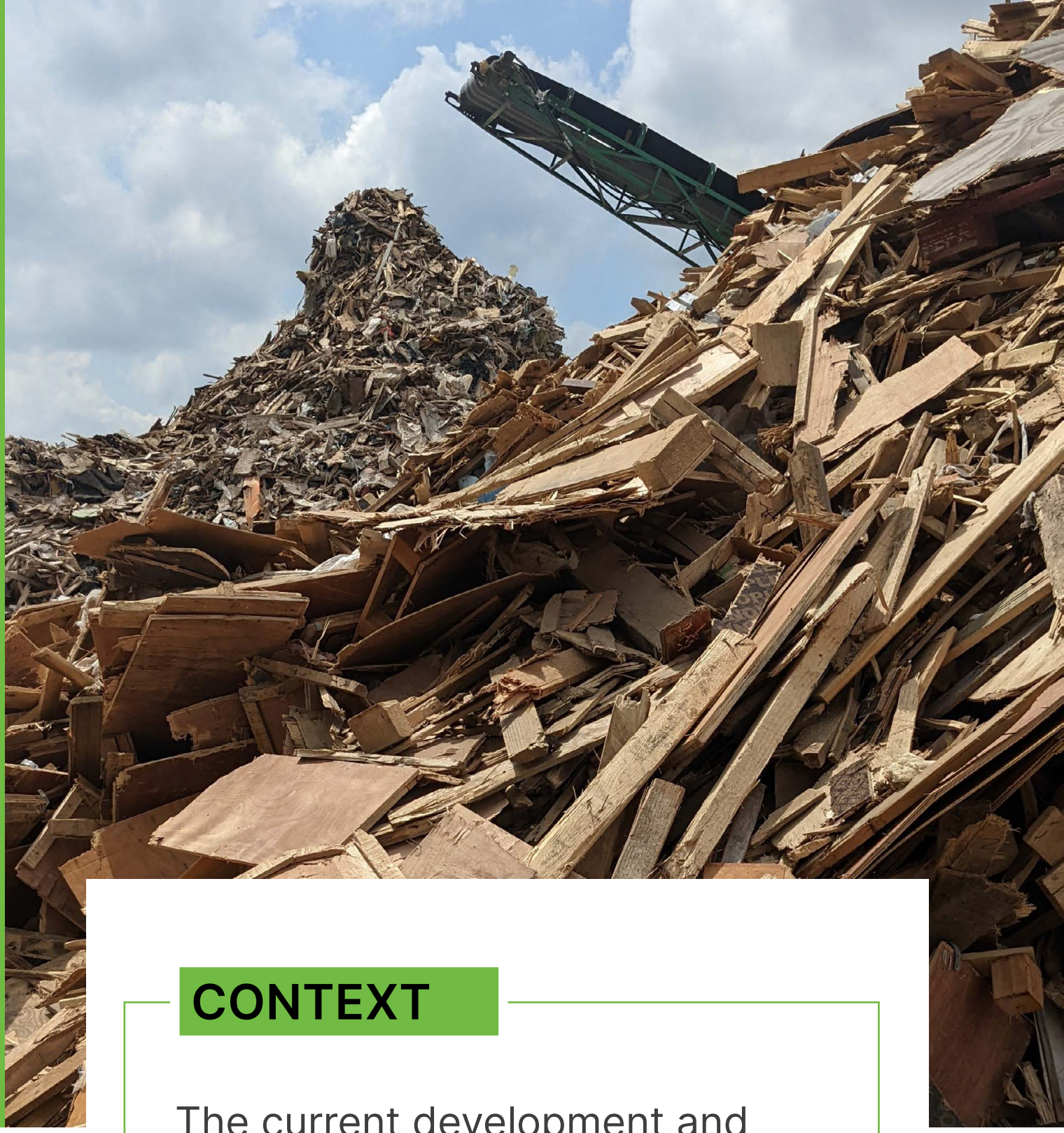
Seeding the growth

To further support efforts to boost secondary markets, this report recommends the development of a province-wide network of Building Materials Reuse Innovation Centres, known as ReHome Depots, to facilitate the material collection, purchase, certification and education around repurposing CRD materials. Additionally, this study recommends the development of Circular Innovation Districts built around ReHome Depots to promote place-based, eco-industrial clustering and foster broader innovation and awareness. As a lead example, Toronto, with provincial support, could establish a ReHome Depot in the old Wellington Destructor and designate the surrounding area as Ontario's first Circular Innovation District. The area would connect the Destructor, Tas Impact's circular building materials project next door, Stackt Market built using used shipping containers down the street, and the Bentway, a park nearby using underutilized space under the Gardiner Expressway.

Empowering the cultivators

To shift the development industry, this report recommends creating a new provincial Build ONce agency to facilitate municipalities integrating circular economy, resilience and high-performance outcomes into Ontario's built environment, while reducing upfront taxes and fees on new developments. Build ONce would first lay the groundwork by harmonizing waste data, developing circular technical standards, and convening expert tables. Then, the Agency (and province) would work to grant municipalities needed legal authority, cut taxes and fees on new developments, and provide the funding to develop, in partnership with key stakeholders, progressive step-based green development, deconstruction, and building performance standards that phase in requirements to reduce operational and embodied carbon, boost resilience and integrate circular requirements. The Agency would provide support to embolden progressive municipalities while building capacity in others to follow, with the goal of shifting new and existing buildings towards a more resilient, circular, low embodied and operational carbon and affordable future.





CONTEXT

The current development and waste system

In 2022, the Ontario construction industry employed 588,000 people (7.6% of the workforce) and contributed $57 billion to Ontario's GDP (Government of Canada, 2023). In 2018, the Ontario waste management sector employed 17,393 workers and generated $2.79 billion in GDP (Clarke & Meyer-Robinson, 2021).

In Ontario, at a general and high level, more extensive construction and renovation projects typically involve a landowner/investor hiring (or is) a developer, who then engages an architect for design and a builder for construction management, who then subcontracts for a range of services. Demolition usually involves the mechanical knocking down of the building. During the project, various types of waste are generated, including materials from demolition, construction offcuts, and components packaging. The builder overseeing the project usually coordinates waste management, often through subcontractors. Some trade subcontractors may either manage their own waste or follow the builder's process, frequently involving the use of a single bin for all waste. Metal is valuable, recyclable and is often pulled from the waste stream. Large amounts of concrete are heavy to transport and are sometimes crushed for reuse in lower-end products. Wood may also be salvaged, but it depends on the contractors, the project, transportation and other considerations.

A failure to divert

Roughly 60% of waste in Ontario originates from the approximately 1.6 million businesses and institutions, including industrial facilities like manufacturers, commercial businesses such as retail stores, restaurants, hotels, and offices, institutions like schools, colleges, universities, and hospitals, as well as construction and demolition projects.

Ontario generates anywhere between 12 to 15 million tonnes of non-hazardous waste every year. In 2018, the CRD sector in Ontario contributed 9% to the total non-hazardous waste, between 900,000 to 1,350,000 tonnes a year (Auditor General of Ontario, 2021).

In Toronto, approximately 30% of non-residential waste is made up of CRD material, resulting in an estimated 366,300 tonnes per year, of which 12% is estimated to be diverted (44,000 tonnes) (This number is downscaled from Ontario-level data) (Beaudoin et al., 2021).

Only 16% of CRD waste in Canada is reused or recycled, while the remaining 84% ends up in landfills (CCME, 2019). Meanwhile, data from 678 Canadian projects certified under the Leadership in Energy and Environmental Design (LEED) revealed an average CRD waste diversion rate of 88%, representing a significant gap between what is done and what is possible (Lighthouse, 2020).

Composition of CRD waste

CRD waste in Canada primarily consists of materials generated during the construction, renovation, and demolition of buildings, roads, and bridges. This waste stream includes a diverse range of materials such as concrete, wood (clean and treated), asphalt, gypsum (the main component of drywall), metals, bricks, glass, plastics, and salvaged building components like doors, windows, and plumbing fixtures (CCME, 2019).

Uncertain composition

In Ontario, the government needs to know what is in its CRD waste. An Auditor General of Ontario report found that the provincial government needs better data on the waste generated by the ICI sector. The province doesn't know how much it wastes, its composition or total or material-level diversion or disposal rates. The Ministry relies on high-level data published by Statistics Canada every two years, which is reported by the waste management industry (Auditor General, 2021). While Statistics Canada provides data on diverted waste in Ontario by material type, it does not offer data on disposed waste by material type, making it impossible to accurately calculate material-specific diversion rates (Auditor General of Ontario, 2021).

Composition of Canadian CRD waste

An analysis by Guy Perry and Associates and Kelleher Environmental (2015) of Canadian CRD waste identified the composition of materials sent to landfill, categorized by "Percentage Total by Weight" as follows: Asphalt (10%), Cardboard/ Paper (1%), Concrete/Stone (4%), Drywall (9%), Metal (3%), Other (29%), Plastic (4%), Wood (40%).

Composition of building materials Guelph-Wellington

A material flow analysis of Guelph Wellington, using data in part from permits, estimated that in 2021, approximately 15.6 kilotonnes of materials flowed out from the built environment, with the majority being Concrete (37%), Wood (18%), Bricks (16%), Other (8%), Mortar (7%), Steel (6%), Drywall (5%), Sand (4%).

The report noted that 58% of the waste came from demolition and 43% from construction, with the rest from renovations (but noted that the number could be higher as a result of non-permitted renovations) (Dillon Consulting, Metabolic & Summit72, 2023).

The City of Toronto estimates using US data

A material flow analysis from the City of Toronto, leveraging US data as a benchmark, reported biomass (including wood (clean, engineered, treated and painted)) represented approximately 40% of CRD waste, mixed materials made up around 29% (including asphalt roofing (10%), drywall (9%), concrete (4%), and cardboard (1%) and plastics (4%), minerals and chemicals (e.g., sand, gravel, crushed stone) accounted for roughly 28%, and metals was about 2.98% (Beaudoin et al., 2021).

LEED projects waste

An analysis of 678 LEED-certified industrial, commercial, institutional (ICI) and multi-unit residential buildings found the following composition of CRD waste: Concrete/Stone (41.3%), Wood (14%), Waste (11%), Metal (5.8%), Asphalt (3.8%), Drywall (4.4%), Cardboard/Paper (2.1%), Plastic (0.7%), Other (0.2%), Organics (0.2%), Foam/Insulation (0.1%), Glass (0.0%) (Lighthouse, 2021).

Gap in data

The data from the various material flow analyses arrive at significantly different projections, using different methods and terms, from incomplete data. Nevertheless, across the data, the highest weight generating materials include: concrete (and related aggregates), wood, bricks, asphalt, and drywall.

Figure 1: Breakdown of CRD materials show data gaps

Material	Guelph Wellington	City of Toronto	LEED Projects	Canadian CRD Waste
Concrete	37%	4%	41.3% (+ Stone)	4%
Wood	18%	40% (biomass)	14%	40%
Bricks	16%	-	-	-
Other	8%	-	0.2%	29%
Mortar	7%	-	-	-
Steel	6%	-	-	-
Drywall	5%	9%	4.4%	9%
Sand	4%	-	-	-
Asphalt	-	10%	3.8%	10%
Cardboard	-	1%	2.1%	1%
Plastics	-	4%	0.7%	4%
Metals	-	3%	5.8%	3%
Mixed Materials* *different definitions of mixed	-	29%	16.6	-
Waste	-	-	11%	-
Organics	-	-	0.2%	-
Foam/Insulation	-	-	0.1%	-
Glass	-	-	0.0%	-

Regulation of the development industry in Ontario

Where and how the built environment is constructed is primarily managed in Ontario through the *Planning Act* and the Provincial Policy Statement. The province also sets growth plans to guide the development of some areas. The province releases the Ontario Building Code, which outlines how buildings should be constructed. The implementation falls on municipalities to prepare and enforce official plans, zoning, engineering standards and bylaws. To settle disputes between municipalities, landowners and proponents, the Ontario Land Tribunal provides arm-length rulings (Ontario Ministry of Municipal Affairs and Housing, 2021).

While the province sets the framework, it is up to the municipalities to set and enforce official plans, zoning rules, building standards and bylaws. (Ontario Ministry of Municipal Affairs and Housing, 2021). Municipalities have a number of front-line regulatory roles that impact the development and waste system, such as regulating construction and demolition through permits, using site plan control and zoning to influence development and building types, managing municipal solid waste, and setting fees, taxes and procurement rules (Lopoukhine, 2023).

Meanwhile, private industry secures land, prepares a development plan and submits it for approval. The municipality approves those plans based on their standards and bylaws (Ontario Ministry of Municipal Affairs and Housing, 2021).

Regulation of the waste industry in Ontario

At the end of life, the Ontario Ministry of Environment, Conservation, and Parks oversees the governance of waste management under the *Environmental Protection Act* alongside the *Resource Recovery and Circular Economy Act* of 2016 (Auditor General of Ontario, 2021).

Under the *Environmental Assessment Act*, the province sets the process to identify and resolve potential environmental problems. All waste management facilities must gain from the ministry an Environmental Compliance Approval (ECA), and generally waste management transportation vehicles need to register under the Ministry's Environmental Activity and Sector Registry (EASR) (Auditor General of Ontario, 2021).

Ontario Regulation 102/94 mandates waste audits and waste reduction work plans for large construction and demolition projects involving buildings with a total floor area of at least 2,000 square metres (Ontario. Ministry of the Environment, Conservation and Parks, 1994a).

Ontario Regulation 103/94 requires the implementation of a source separation program for large construction and demolition projects for buildings with a total floor area of at least 2,000 square metres. Under the regulation, source separation is required, but there are no requirements for diversion (Ontario. Ministry of the Environment, Conservation and Parks, 1994b).

Status of Ontario's waste system

Ontario set a diversion goal but fails to take action

In 2017, the Ministry aimed to reduce per capita waste disposal and set diversion targets of 50% by 2030 and 80% by 2050 for ICI and residential sectors (Auditor General of Ontario, 2021). Waste diversion efforts in Ontario have stagnated at around 25% (Ontario's Regulatory Registry, 2023).

The ICI sector is crucial for meeting these goals. Yet, the Ministry hasn't taken sufficient action to decrease ICI waste or effectively track progress, risking the province's landfill capacity and target achievement (Auditor General of Ontario, 2021 & 2023).

Running out of landfill space in Ontario

In Ontario, the waste system is impacted by low landfill tipping fees and even lower tipping fees in the United States, leading to 27% of the province's waste being landfilled in the United States (OMWA, 2021). Meanwhile, Ontario's landfill capacity is shrinking, with over 60% of its waste disposed of in just seven landfills, which are expected to reach capacity within the next 9 to 14 years, contingent on U.S. export availability (OMWA, 2021). With a roughly 10-year lead time to build new landfills, the waste association has called on the Ontario government to expedite the landfill approval process (OMWA, 2021).

CRD waste externalities

Carbon pollution and biodiversity loss

The global demand for resources is rapidly increasing, with the building sector accounting for 40% of global resource usage and expected to double by 2060 (OECD, 2019). This sector also contributes significantly to global carbon emissions, responsible for 39% of energy- and process-related emissions as of 2020 (UNEP, 2021). The extraction of raw materials is a major contributor to biodiversity loss and water stress, with G20 countries accounting for nearly 75% of global materials use (OECD, 2021).

In Canada, the construction industry significantly contributes to landfill waste and carbon emissions. 3.4 million tonnes of construction materials are disposed of in landfills annually, accounting for approximately 1.8 million tonnes of embodied carbon (Delphi, 2021). If embodied carbon emissions are added to operational carbon emissions, the building sector's overall carbon emissions jump from 17% to 30%.

The building sector accounted for 24% of Ontario's total carbon emissions, but that number is much higher in major cities, accounting for 58% of emissions in Toronto (City of Toronto, 2022).

Circular development and waste system

There are three main interrelated strategies in a circular built environment: adapting and repurposing existing structures, designing new buildings for adaptability, and reusing building materials (Bansal et al., 2024).

In a circular system for the reuse of materials, an architect, likely working integrated with the builder, prioritizes adaptability, durability, and the ability to deconstruct. The designer would choose reclaimed or recycled materials or new materials for their low embodied carbon, recyclability, longevity, environmental impact and potential for reuse. During construction, builders and subcontractors minimize waste generation and segregate their waste for recycling and repurposing.

The operational phase of buildings focuses on energy efficiency and reducing environmental impact through design, the use of technology, renewable energy, and water management systems. At the end-of-life phase, buildings are carefully deconstructed, and waste is segregated on-site to further facilitate the recovery, recycling, and reuse of materials.

The waste would be stored at a centre where it would be prepared for recycling or remanufacturing; it would then be transformed or remanufactured into usable materials and distributed for new end-uses or disposal in a landfill (Brandão et al., 2021).

Materials

Metals

Metal is considered to have significant value on the secondary market and is diverted throughout the end-of-life process—on site during demolition, by haulers, at transfer stations and at landfill sites—demonstrating the clear impact of market signals on the waste system (Lopoukhine, 2023).

Concrete and aggregates

Ontario produced roughly 161 million tonnes of mineral aggregates in 2019 (Ontario Aggregate Resources Corporation, 2019).

In a Yang et al. study (2022), concrete represented 60% of material outflows from the Dutch residential building sector and is a major component of new construction demands. Its high availability and the relatively established recycling processes make it one of the materials with the best potential for reuse. However, with limitations on the amount that can be used in new construction, the study anticipates a surplus of concrete by 2035. The study also noted that clay bricks made up 24% of material outflows, but their usage in new constructions is minimal, which would lead to a significant surplus (Yang et al., 2022).

Materials like brick and glass can be incorporated up to 1% into Recycled Concrete Material (RCM), as per Ontario Provincial Standard Specifications (OPSS). RCM is derived from returned concrete, construction, and demolition waste. Its primary applications include use as a road base and backfill, with limited incorporation into concrete mixes. RCM is processed into products such as Recycled Granular A, B1, B3 (created from returned concrete) or Granular A and B (generated from CRD waste). These materials can also be used directly or blended to replace virgin quarry materials. In concrete road works, RCA is utilized to construct sidewalks, concrete pavements, and curbs, either as a base layer or as part of new non-structural concrete. In the US, 65% of RCA is used in road base and only 6.5% in new concrete mixtures (Circular Economy Leadership Canada & Circular Innovation Council, 2022).

Lack of adoption of recycled aggregate in Ontario Municipalities

Although Ontario has provincial standards with respect to the use of recycled aggregate materials in infrastructure projects, municipalities have discretion in the implementation of these standards—and in their local policies. As a result, practices can vary widely by municipality.

As of 2018, many Ontario municipalities either prohibit or severely restrict the use of recycled aggregates in new road construction and municipal projects. Generally, the use of these materials is limited to specific applications like construction access roads and bicycle paths, while broader applications in pavement bases, engineered fills, and other structural layers are less accepted. There is also a notable variation in the adoption and encouragement of recycled materials across different municipalities, with Toronto, Cambridge, and Markham showing more progressive practices, whereas Peel Region, Oshawa, and Mississauga lag behind (Graham, 2018).

Growing opposition to aggregate quarries in Ontario

The Reform Graving Mining Coalition, composed of 41 environmental, community and agricultural organizations along with 20 municipalities, called for a moratorium on the approval of new aggregate quarries in Ontario. The coalition said that Ontario had already approved the extraction of 13 times more aggregate than is actually removed each year and, therefore, that no more pits or quarries are needed (Reform Gravel Mining Coalition, 2022).

Aggregate industry lacks oversight

According to a 2023 Auditor General of Ontario report, the environment ministry lacks effective systems and processes to manage the aggregate industry's compliance with the *Aggregate Resources Act* and related regulations, resulting in high non-compliance and inadequate oversight. The report highlights a lack of incentives for using recycled aggregates, a scarcity of experienced inspectors, infrequent inspections, which is leaving a controversial industry without proper oversight (Auditor General of Ontario, 2023).

Wood

In CRD waste, there are multiple types of wood: clean, engineered, painted or treated. Clean wood is not treated with chemicals, paint, glue or coatings, whereas the rest have been altered, limiting their reuse opportunities (Canadian Council of Ministers of the Environment [CCME], 2019).

Reclaiming clean wood presents difficulties, with source separation identified as a crucial step in the process. While chipping reclaimed wood into particle board represents a viable recycling path, full recovery and reuse of wood is preferred for its potential to contribute to resource conservation (Hradil, 2014). In Canada, clean wood waste is commonly transformed into mulches, animal bedding, and recycled-content wood furniture (Guy Perry and Associates and Kelleher Environmental, 2015).

Large timbers are easier to salvage due to their size and ease of removal without damage, whereas smaller dimension lumber, often laden with nails and shorter in length, is rarely salvaged. Despite no technical barriers to reusing both in structural applications, reused wood must be graded for structural use (Webster, 2002).

Softwood's outflow, if recycled, would meet full demand for softwood in the Dutch residential building sector almost immediately, but has a high replacement rate of 90% (i.e., 90% of virgin softwood could be replaced with waste softwood), according to a Dutch study (Yang et al., 2022). The study doesn't mention how the replacement would be achieved through one-to-one replacement of structural components or mass timbre or prefabrication projects. Prefabrication is much higher in Northern Europe, around 45% of new housing construction, compared to North America where the market is growing but still remains in its infancy (Ribeirinho et al., 2020).

Asphalt and asphalt shingles

Asphalt roofing shingles can be a valuable recycling resource because of their quantity in CRD waste, ease of separation from other wastes, and the existence of recycling technology and markets. Their use in producing asphalt pavement offers cost savings and may improve roadway performance (Booz Allen Hamilton, 2013). Recycled asphalt shingles can also be repurposed for new shingles or used as a fuel source (Guy Perry and Associates and Kelleher Environmental, 2015).

The use of reclaimed asphalt pavement (RAP) in hot mix asphalt is permitted in Ontario, with different municipalities incorporating varying percentages into their paving projects, depending on individual municipal specifications. In 2023, hot mix asphalt projects that contained RAP used an estimated 15% of recycled content (Ontario Good Roads Association, 2023).

RAP is primarily used for road bases and backfills, they have limited use in concrete mixes due to potential contamination concerns (Circular Economy Leadership Canada & Circular Innovation Council, 2022). In 2018, the City of Richmond initiated a pilot to use 40% recycled asphalt in municipal roads to build market confidence, paving 800-metres of road. The pilot will be evaluated yearly for performance (Circular Innovation Council, 2021).

Gypsum

In Canada, gypsum from offcuts and demolition waste can be turned into recycled-content wallboard, used as a soil amendment to balance PH levels, or utilized as a fuel (Guy Perry and Associates and Kelleher Environmental, 2015). It can also be used in concrete materials, as part of recycled aggregates, cement production, plaster, and blocks and walls (Jafari, 2024).

Plastics

The construction sector is one of the largest consumers of plastics. In Canada, the sector is responsible for 26% of the plastic entering the market (Santos, 2023). Plastics suffer from a lack of established recycling processes or economic barriers to recycling (Yang et al., 2022).

Insulation

Insulation and high-performance materials, due to their specialized nature, potential contamination, and the absence in older buildings would continue to require ongoing supply of virgin materials (Yang et al., 2022).

Mixed CRD waste

Some mixed CRD loads in Ontario are ground up and used as fuel for boilers in greenhouses or as roads or daily cover on landfills; so it goes in or on top of landfills but either way it goes to landfill (Lopoukhine, 2023).

Embodied carbon of materials

The Carbon Leadership Forum (CFL) Baselines estimate the average greenhouse gas emissions for construction materials manufactured in North America, derived from industry-wide Environmental Product Declarations and other data sources. The embodied carbon of the more voluminous building materials, based on CLF Baselines, are:

- Aluminium: 10,250-12,700 kg CO2e per metric tonne,
- Steel: 753-2,440 kg CO2e per metric tonne,
- Cement: 589-922 kg CO2e per metric tonne,
- Gypsum Board: 207-503.9 kg CO2e per 1000 ft2, and
- Wood and Composites: 63.12-361.45 kg CO2e per m3 (Carbon Leadership Forum, 2023)

Benefits of a circular system

Reclaimed material GHG savings

Research found that selective deconstruction can significantly reduce carbon emissions, with a 59% per capita decrease compared to landfilling, while recycling and downcycling practices can result in a 36% decrease (United Nations Environment Programme, 2023). Another study found that the GHG reductions from urban mining in the Dutch residential building sector pales in comparison to using low-carbon electricity. Still, a combination of both clean electricity and urban mining can lead to a 40% decrease in annual GHG emissions by 2050 relative to 2020 levels (Yang et al., 2022).

Broader GHG reductions from circular solutions

Broader circular economy policy adoptions could significantly reduce the embodied carbon of materials like cement, aluminium, steel, and plastics. By 2050, applying these circular strategies could cut global carbon emissions from these industries by 40% (Ellen MacArthur Foundation, 2021).

Resilience in supply chains

A circular supply of building materials that are locally sourced provides the opportunity to increase the resilience of supply chains and mitigate disruptions from climate-fuelled natural disasters, pandemics or other volatility in the market (OECD, 2020).

Improved biodiversity

Circular economy practices not only halt biodiversity loss but also promise a return to the biodiversity levels of 2000 by 2035. This would be achieved through policy interventions and business actions, such as regenerative production practices and business models that lengthen product lifespans, enhance usage rates, and minimize waste, in sectors like food and agriculture, buildings and construction, fibres and textiles, and forestry (Forslund et al., 2022).

Project cost savings with deconstruction

Adopting deconstruction processes instead of demolition, can reduce project costs and even yield a marginal profit. For instance, deconstruction was found to be 37% cheaper for certain building types. The cost-effectiveness varies based on the building type and value of the salvaged materials, but financial incentives from the government and reduced equipment costs can help offset the higher labour costs (Charef, 2022).

Economic benefits of embracing the circular economy

A Canadian study on waste prevention interventions across six sectors, including construction and manufacturing, reveals the potential of circular economy practices to reduce waste by 4.9 million tonnes, cut 5 million tonnes of carbon emissions, create 20,000 jobs, and generate $41 billion in additional revenue or cost savings (National Zero Waste Council, 2021).

More resilient companies

Companies with higher levels of circularity exhibit a lower risk of debt default, emphasizing the financial stability and performance benefits of investing in circular business models (Shorthouse et al., 2024).

METHODOLOGY

Research questions

This study is guided by one primary research question and several secondary questions aimed at uncovering Ontario's provincial policy landscape to encourage the circular use of CRD waste and enhance the circular-built environment. The main question this research seeks to answer is: What are innovative, underused, or cross-sectoral Ontario provincial policy options available to foster the circular use of CRD waste and grow the circular built environment? The secondary questions delve into the current provincial policies, identify innovative and underused options, explore potential barriers, and examine the roles of municipal governments.

Methods

To address these research questions, this study leveraged multifaceted research design incorporating a literature review, stakeholder interviews, and a systemic policy analysis, followed by policy design.

Literature review

The review of academic literature, industry reports, and international case studies provided a comprehensive understanding of the barriers and opportunities to shift the current system and best practices related to the circular use of CRD waste. This effort illuminated the global and Ontario-specific landscape of existing knowledge and practices.

Stakeholder interviews

Semi-structured interviews with a wide range of stakeholders from the construction, urban planning, government sectors, academia, and non-governmental organizations provided an expanded understanding of solutions to shift the current system. These discussions offered insights into diverse perspectives on the challenges and opportunities associated with enhancing circularity in CRD waste management and the built environment.

Systemic policy analysis

An analysis of existing provincial policies and economic relationships related to construction and waste management was undertaken to identify gaps and potential areas for systemic interventions. The aim was to pinpoint opportunities for policy enhancements or introductions that could facilitate a more circular approach to CRD waste management.

Participatory design: Generative and foresight tools

The workshop, involving municipal officials, policy advisors, waste and building industry professionals, leveraged generative design and foresight tools to engage stakeholders in actively creating innovative policy solutions and envisioning responses to future scenarios. This method fostered collaborative ideation among diverse groups, ensuring the generation of practical and forward-thinking strategies for promoting the circular use of CRD materials.

In the workshop, participants in groups of four to five leveraged a generative design toolkit, containing AI-created 3D graphical representations of materials, services, and features of a reclaimed building materials centre (i.e., a ReHome Depot), designed their idealized version of a reuse centre. Following the creation of their reclaimed building materials depot, they used a Futures Wheel to explore the implications and developed responses to a series of foresight scenarios.

Rationale for methods

The chosen methods align with the complex and interdisciplinary nature of the research questions. The literature review provided a foundational understanding, stakeholder interviews offered practical insights and diverse viewpoints, the systemic policy analysis helped identify specific leverage points, and the participatory design helped dig into finer details of policy design. This combination ensured a comprehensive approach to designing effective and innovative policy options.

Stakeholders

The research was informed by interviews with a wide range of stakeholders, including experts in the circular economy and waste management, municipal officials, provincial and federal policy advisors, deconstruction and recycling professionals, academics, architects, embodied carbon experts, engineers, reclaimed materials vendors, consultants, and climate and circular economy focused non-profit organizations. These stakeholders provided valuable insights into the current challenges, opportunities, and innovative practices related to the circular use of CRD waste and developing a circular built environment.

FINDINGS

Barriers
to a circular CRD waste system

Regulatory and policy barriers

Little producer responsibility

In Ontario, there are no regulations that hold manufacturers accountable for the environmental impact of their construction products throughout their lifecycle. In 2009, provincial ministers agreed to implement an extended producer responsibility program for construction and demolition waste within eight years of the adoption of a Canada-wide Action Plan for Extended Producer Responsibility, but Ontario has failed to follow through (Canadian Council of Ministers of the Environment, 2009).

Insufficient definitions and number and use of standards

A lack of engineering standards hinders the adoption of circular building practices. Standards underpin the building code, while providing uniform guidelines for the application of materials and methods. There needs to be more shared definitions in standards that define circular practices, for instance, should the chipping of clean wood and the crushing of concrete be considered recycling or is it downcycling? (Goodland & Walsh, 2024).

Researchers pinpointed a total of 54 Canadian and International standards that are either under development, underused, widely used that either integrate or could integrate considerations related to the circular built environment. Out of 54, there was only one identified in material salvage and two in deconstruction, making the sector significantly under-developed in technical standards (Goodland & Walsh, 2024).

Limited circularity in the building code

In Ontario, the province oversees the development of the Ontario Building Code and as part of a harmonization effort across the country, is adopting a version of the federal model building code. The current model code needs to tackle a number of related environmental challenges, such as low-embodied carbon materials and building high-performing, resilient or circular buildings. The next iteration of the model code in 2025 is expected to cover operational carbon and then embodied carbon in 2030, concurrently with a model retrofit code to act as a guide for energy efficiency improvements during renovations. The retrofit code holds the potential to incorporate circular solutions (Goodland & Walsh, 2024). Resilience measures to make homes safer in the face of increasing climate impacts may be incorporated into the 2030 code (Ha, 2023). The model code is only as effective as the version Ontario implements; to date, Ontario has opted not to adopt more stringent standards.

Globally, the use of recycled materials in construction is hindered by a lack of supportive building codes, which fail to facilitate the supply and demand for circular components made from reusable and renewable materials (United Nations Environment Programme, 2023).

Certification of reclaimed materials is complex

This process to certify reclaimed materials is often complex and materials like dimensional lumber, initially used for framing, are relegated to non-structural uses in their subsequent life. Various methods, including on-site inspections, certification services by accredited bodies, test reports, or engineering reports, can be used to ensure compliance with the code. However, the exact process varies by jurisdiction, with some requiring more extensive documentation than others (Goodland & Walsh, 2024).

The Ontario Building Code does not include provisions for circular building practices, hindering sustainable construction. For instance, building codes do not address the incorporation of salvaged materials in construction projects, leaving designers to seek out alternative solutions, which can increase both time (cost) and the risk associated with a project (Goodland & Walsh, 2023). Engineers tasked with regrading wood for instance, must identify its species and grade (and are aided if the materials

original location and age is known). Generally, reclaimed wood because of its appearance will be downgraded one grade from its actual strength (Webster, 2002).

In Ontario, to use materials that are non-standard, the provincial government set up the Ontario Building Code's Alternative Solutions framework. This process is often run as a cost-recovery process overseen by municipal building services departments, creating a financial barrier to non-traditional proposals (Lopoukhine, 2023).

Low-cost bidding procurement

The focus on the lowest initial cost in public and private procurement often leads to choices that do not align with sustainable, long-term objectives. Focusing solely on price can lead to poor quality, the hiring of unqualified contractors, and contractors submitting unrealistically low bids intending to recoup costs through change orders and claims. This practice often leads to cost escalations, while distorting the market and negatively impacting project outcomes (Bedford, 2009).

The Environmental Compliance Approval (ECA) process is complex

Obtaining Environmental Compliance Approval (ECA) for waste management and recycling operations, including site plan alterations, is a lengthy, complex, and uncertain process, with no expedited paths for recycling operations. Today's ECAs are more restrictive and challenging to alter, reducing the ability to innovate or to adapt to market changes. Further they come with high upfront financial assurances that discourage risk-taking (Lopoukhine, 2023).

Limited regulation and enforcement

Less than 1% of the 140,500 construction and demolition establishments in Ontario are regulated under ICI waste regulations as of 2019 (Auditor General of Ontario, 2021).

Of the sites that were inspected under Regulation 103/94 (source separation) resulted in a compliance rate of 86%. In ten years, the ministry had not inspected any demolition sites because the ministry says demolition happens too quickly; their short-term nature, the ministry said, made it difficult to audit (Auditor General of Ontario, 2021).

Buildings controlled by ridged municipal rules

The Province's Growth Plan and municipalities official plan, such as Toronto's Official Plan, aim to promote high-density development in specific areas and mid-density along "Avenues", while safeguarding most of the city's geographical area from new denser developments. These high-development areas, zoned for mixed-use and suitable for mid to high-density development, must nevertheless obtain zoning bylaw changes. This requirement often leads to a lengthy, costly (due to fees and taxes), and uncertain process. These limitations drive up the cost of land and limit the type of new housing being built (Clayton & Petramala, 2019).

The interplay of stringent zoning rules, NIMBYism (Not In My Backyard), and certain discriminatory attitudes leads to projects becoming economically infeasible due to prolonged delays and subjective approval processes. This stagnation is compounded by the complexity and inefficiency arising from overlapping jurisdictions among different government levels, leading to unclear responsibility and ineffective coordination (Moffat, 2023).

Municipal funding, capacity and structure

Municipal governments face several structural barriers that limit their operational efficiency. These include micromanagement by higher levels of government, a misalignment between municipal duties and fiscal capabilities, overlapping jurisdictions, ambiguous cost-sharing arrangements with provinces, and poor regional governance structures among neighboring municipalities (Hachard, 2020).

Stakeholder insights: Slow adoption of embodied carbon requirements

Compared to the UK, Canada has been slow to adopt embodied carbon requirements, reports a UK embodied carbon expert. Embodied carbon requirements have also faced hurdles at the municipal level. Stakeholders report municipal officials have been hesitant to introduce requirements due to significant pushback from the building industry on efforts to decarbonize operational carbon. Additionally, there is concern about increasing costs during an affordability crisis."

Life cycle assessments (LCA) are used to calculate embodied carbon of new builds. Currently, LCAs do not use consistent material databases, resulting in varied results (Goodland & Walsh, 2024). At the municipal level, there is uncertainty in the right embodied carbon standard and the accuracy of the LCA tools that support accurate accounting of embodied carbon emissions, stakeholders report.

Stakeholder Insights: Embodied carbon limited to new builds

Stakeholders say there are limitations to using embodied carbon to shift to a more circular system. Currently, embodied carbon assessments are primarily applied to new constructions, with no established policies or easy methods to evaluate the benefits of using low-carbon materials in the context of updating existing structures. This oversight means that the potential carbon savings from preserving and improving existing buildings, as well as the materials used in these processes, are not adequately accounted for and valued under current practices.

Economic and market challenges

Economic viability concerns

Currently, the overall costs of circular buildings are perceived as higher than traditional buildings, primarily because they are still evaluated using a linear cost model, which includes land, materials, design, and construction expenses, but does not include life cycle costing, that would factor in the total cost of building ownership (Thelen et al., 2018).

Stakeholder Insight: Lack of an economic strategy presented to decision makers

Despite the economic benefits of a circular economy, a leading innovation and economic public policy political advisor at both the provincial and federal level said in his many years of government, he had never been presented with an economic proposal for circular industrial development.

Housing crisis used to keep standards low

The Canadian Mortgage and Housing Corporation projects that under the continuation of current construction trends, the housing stock in Canada will approach 19 million units by 2030. However, to achieve housing affordability, their central scenario anticipates a need for over 22 million units (CMHC, 2022). Over the last ten years, housing prices in Ontario have shot up 180% while average incomes have only grown 38% (Ontario Housing Affordability Task Force, 2022).

With this context, the home building industry resists changing the way it builds. They argue that any alteration to the current building methods, aimed at enhancing sustainability or energy efficiency, will further increase costs, exacerbating the affordability crisis (Lee, 2020).

Limited market for reclaimed materials

The market for reclaimed building materials is not sufficiently developed, making sourcing materials a challenge. Waste management facilities say unstable end markets are a key barrier to material diversion. Despite available technology, high processing costs can make operations unsustainable. In 2013, an Ontario facility shut down after nine months of operation because recovering wood, concrete, drywall, and metal from construction and demolition waste was uneconomical (Auditor General of Ontario, 2021). Though a stakeholder familiar with this operation relates there were other poor managerial choices that also impacted the business. As of 2018, many Ontario municipalities either prohibit or severely restrict the use of recycled aggregates in new road construction and municipal projects (Graham, 2018).

Subsidies for virgin materials

A strong reliance on new, virgin materials for construction undermines efforts towards circularity. Subsides for virgin materials are cited both in international (Thelen et al., 2018) and domestic reports (Delphi, 2021) on barriers. For instance, U.S. officials have long asserted that the stumpage fees paid by Canadian firms to provincial governments for logging on Crown lands are excessively low, which is a subsidy. Canada disputes this charge and has won World Trade Organization rulings against US tariffs (McCarten, 2023).

Low cost to dump waste

In comparison to the US, Ontario and other Canadian provinces generally have higher ICI waste tipping fees, with Ontario's 2019 average at $109.86 CAD per tonne, versus the US national average of $64.34 CAD per tonne. Despite higher tipping fees in Ontario, the overall cost of waste disposal for generators, when considering transportation, is roughly comparable between using US landfill options and Ontario-based options (AET Group Inc., 2021).

Michigan, one the lowest cost jurisdictions where a significant amount of Ontario waste ends up, is proposing an increase in landfill fees from 36 cents to $5 per tonne to deter out-of-state waste imports and align fees with regional averages, threatening this low-cost export destination (Hermani, 2024).

Industry and operational barriers

Construction labour skills shortage

In 2022, the Canadian construction industry faced a record-high vacancy rate exceeding 80,000 positions (CIBC Capital Markets, 2023). 22% of Canada's current construction trades workforce is expected to retire over the next decade, requiring 245,100 workers to replace the ageing workforce. Despite a heightened level of recruitment, the industry is expected to be short 60,000 workers in ten years' time (BuildForce Canada, 2023) (CIBC Capital Markets, 2023).

Under an accelerated climate action scenario, the green retrofit economy could generate almost two million jobs over the next three decades, which averages to about 66,667 jobs per year (Delphi, 2022). With a need to retrofit and build millions more homes, a labour shortage would have devastating consequences on the sector's ability to solve dual housing and climate crises.

Low productivity gains

Globally, labour-productivity growth in construction has averaged only 1% a year over the past two decades, compared with growth of 2.8% for the total world economy and 3.6% in manufacturing. If construction-sector productivity were to catch up with that of the total economy, this would boost the sector's value by an estimated $1.6 trillion, adding about 2% to the global economy (Barbosa et al., 2017). Canada's productivity in the construction industry has also lagged the rest of the economy by a wide margin (Tal, 2023).

Lack of technological adoption

In 2016, McKinsey ranked the construction industry second last to digitize (in terms of digital assets, digital usage, and digital workers), only ahead of agriculture (Gandhi, Ramaswamy & Khanna, 2016). In 2019, venture capital investment in construction technology outpaced non-construction funding by a factor of 15, showing signs of change in the industry. (Bartlett et al., 2020). Globally, there is a lack of carbon transparency within the construction industry and it requires the adoption of standardized labelling, lifecycle assessments (LCAs), and the support of digital tools to improve accountability (United Nations Environment Programme, 2023).

Under adopted BIM technology

Building Information Modelling (BIM), involving the creation and management of a digital model that represents the physical and functional characteristics of a building project, has been slow to adopt in Canada (Moazzami et al., 2020). Denmark led BIM adoption globally, mandating it for public projects in 2007 and expanding to all projects by 2011, with countries like Finland, Singapore, the UK, and France following with full mandate (and other countries following suite) (Cao et al, 2019).

BIM offers significant advantages over traditional project delivery methods in design, construction, and operation phases, including finding conflicts between components,

enhanced visualization, code compliance, cost estimation and improved scheduling, which facilitate better space planning and maintenance during operation. Further BIM fosters improved collaboration among stakeholders across the project lifecycle (Cao et al, 2019).

BIM could enhance circularity in buildings by optimizing project and material efficiency and for end-of-life management. At the end-of-life phase, it can provide demolishers with visual tools for identifying material locations, accurate quantity assessments, and demolition planning, but currently that is a niche and under-developed community in the broader BIM world (Charef, 2022).

Stakeholder insights: Lack of circular infrastructure

Stakeholders say the current waste management infrastructure, particularly transfer stations, faces significant challenges in handling construction and demolition waste effectively. Transfer stations are primarily designed to receive household goods rather than commercial-scale waste, lacking the capacity for organizing, sorting, and managing used building materials. It is often more convenient and cost-effective for collection sites to mix all waste into a single bin, despite initial sorting efforts. From collection and hauling to processing, there needs to be more alignment of incentives at every step of the way, say stakeholders.

Challenges in source separation at construction sites

Source separation plays a key role in enhancing recycling efficiency and reclaimed material quality, limiting the contamination of materials and facilitating their reuse in new construction projects. Limitations such as logistical complexities and the need for new practices hinder effective source separation (European Environment Agency, 2022).

Some research on source separation emphasizes the need for specific technology and economic considerations in deciding the best practices, suggesting off-site sorting at specialized facilities as the ideal approach. Other studies advocate for on-site separation, citing benefits like reduced landfill waste and easier adoption of reverse logistics (Brandão et al., 2021).

Stakeholder insights: Source separation is important for best use

Stakeholders say that to get the highest and best use out of CRD waste, source separation is a key first step, but space is a constraint on many dense urban redevelopment projects, especially if reuse of deconstructed materials need to be stored, which presents logistical challenges.

Stakeholder insights: Space constraints in large urban markets

Stakeholders in the deconstruction, reclaimed materials and recycling industries all point to space and cost pressure in large urban markets (e.g., Vancouver and Toronto) as a major barrier to their businesses, especially in an uncertain and variable market where the material flow is non-linear. Stakeholders need larger warehouses and fear redevelopment and a loss of space in urban locations.

Supply chain challenges

Establishing a reliable supply chain for circular materials is fraught with logistical and quality control challenges. A good illustration of this barrier is the work Quebec did in trying to increase the circularity of gypsum. Quebec's *Regroupement des Récupérateurs et des Recycleurs de Matériaux de Construction et de Démolition du Québec* (3R MCDQ) analysis to increase the reusability of Gypsum found that gypsum circularity faces challenges such as inconsistent sorting at source, limited recycling facilities, low resale value, underdeveloped markets for recycled gypsum, high transportation costs, regulatory hurdles, and quality variability, hindering its integration into a sustainable waste management and reuse framework (3RMCDQ, 2020). The only gypsum recycler in the province, Recycle Gypse Québec, was built to process 10,000 tonnes a year. Still, construction scraps and demolition waste if recycled added up to upwards of 225,000 tonnes of potentially usable product (3RMCDQ, 2019).

In 2017, RECYC-QUÉBEC spearheaded a pilot project in collaboration with 3R MCDQ and Recycle Gypse Québec to optimize gypsum waste management. The project focused on trialling source-separation techniques for gypsum and establishing dedicated drop-off points. Although the initiative aimed to increase gypsum recovery and reduce contamination, it faced a significant setback when the only gypsum recycler in the province shut down in December 2018, impacting the project's feasibility (3RMCDQ, 2019).

According to a Dutch study, harvesting reclaimed materials from the waste stream can supply only a limited amount and variety of building materials. Continued population growth, concentration of materials in major cities, material quality of reclaimed materials, and a mismatch in timing of demolitions and materials extracted compared to the needs of new builds will limit the growth of the market (Yang et al., 2022).

Societal and cultural barriers

Cultural and perception barriers

There is a hesitancy in using reused materials for building projects because of the limited research on their long-term performance, and when these materials do not meet existing code standards or fall outside the building code's scope and become an "alternative solution" that requires submitting technical evidence to the local authority, which can become a time and cost prohibitive exercise (Goodland & Walsh, 224).

In Finland's advanced circular economy relative to North America's market, material reuse faces challenges in adoption, where high labour costs and perceptions of inconsistent quality and quantity hinder its progress (Hradil et al., 2014).

Status quo bias

A Dutch study investigating the adoption of sustainable building practices among building professionals identified significant psychological barriers, including conservatism, which limited adoption. Status quo bias, confirmation bias, and the complexity of information were found to be major barriers to the adoption of sustainable practices (Hofman et al., 2022).

Societal insecurity

The growing sense of insecurity in contemporary society is deeply intertwined with the dynamics of capitalism, which is increasingly seen as a system that concentrates wealth and poverty and perpetuates insecurity, says activist and writer Astra Taylor. Factors like worsening climate conditions, deteriorating health systems, weakening institutions, unaffordable housing, and stagnant wages contribute to this sense of insecurity. People are finding that even as they overcome one financial hurdle, such as debt, they remain vulnerable to other crises like medical emergencies or job loss, underscoring the pervasive nature of insecurity under the current system (Fisher, 2023).

Stakeholder Insight: Lack of a sustainable materials ethic in Canada

A stakeholder with European roots said Canada has a legacy of poorly built homes, unlike most European countries, and with abundant resources lacks a sustainable materials ethic. This analysis plays out in the data, where Canadians lead the developed world in garbage production. Canada generates 720 kilograms of waste per person each year, which is double the amount produced by individuals in Japan and is 7% higher than that of the United States (Wilkins, 2017).

Policy opportunities

According to the Canadian Council of Ministers of the Environment (2019) report on CRD waste management policies, there are over a dozen policies that can help improve the circularity of CRD materials. The policies geared to create accountability, limit disposal options, align financial incentives, improve diversion processes, strengthen secondary markets, and build knowledge and accountability are seldom effective in isolation; an approach that combines multiple policies is necessary to achieve meaningful change.

Create accountability: Waste management plans

Waste Management plans require producers, builders and facilities to develop and execute an end-of-life strategy to divert CRD materials from landfill. The requirement for a plan can be triggered through a municipal building permit process, a facility operating licence, building codes, government procurement or third-party building certifications. The plans usually require proponents to outline which materials will be separated, diverted, reused and recycled, leveraging standards, percentages, reporting, certification and/or deposits to achieve policy success (Canadian Council of Ministers of the Environment [CCME], 2019).

London's circular economy statements

Launched in the London Plan 2021, applications for building over 150 residential units, over 30 metres tall outside the City of London (UK), or being located on specific designated lands, must now produce circular economy statements. The statements are provided at the pre-application, planning application, and post-construction stages and encourages early collaboration. The statements seek to understand strategies used for maximizing the reuse and recycling of demolition materials, minimizing new material demands, onsite waste management, and reporting on how the waste will be managed and overall performance monitored. Additionally, the process allows for 'compliant' and 'pioneering' statements, to encourage the use of creative circular approaches (Greater London Authority, 2021).

Stakeholder insights: Phase in the audits to collect baseline data

The process for London's Circular Economy Statements is currently focused on consideration rather than achieving high circularity outcomes, reports a UK embodied carbon academic. London is currently in the data collection phase to understand the baseline; there have not been instances where projects were denied permission based solely on low circularity, he said.

Stakeholder insights: Build the auditing process off the back of embodied carbon requirements

The introduction of circular audits was built on top of the framework established by the implementation of embodied carbon requirements. In the process of calculating the building's embodied carbon and detailing every material used, the circularity

audits add a qualitative step where the builder explains how they are reducing embodied carbon through circularity, he said.

Stakeholder insights: Build capacity across local governments

London's circular economy leadership is much more advanced than other UK municipalities who lack the experience or capacity to follow suit, signalling a need for upskilling, standardization, and collaborative support in order to scale this process to a wider area and make it more efficient, he said.

Ontario's ineffective work plans

Ontario requires waste audits and waste reduction work plans for large construction and demolition projects for buildings with a total floor area of at least 2,000 square metres (Ontario. Ministry of the Environment, Conservation and Parks, 1994a). Compliance has historically been poor, largely because many operators in the construction and demolition sector view these workplans as mere administrative tasks (Canadian Council of Ministers of the Environment [CCME], 2019).

Create accountability: Producer responsibility

Producer responsibility programs typically have well-defined product categories and with a corresponding responsible producer/sector. There are defined roles, stewardship plans, performance and reporting standards, and penalties (Canadian Council of Ministers of the Environment [CCME], 2019).

France launches EPR system for CRD

Starting from January 1, 2022, France implemented an EPR system for construction or demolition waste, where producers pay fees to a third-party organization that manages collection, sorting and recycling services. France also has complementary policies requiring mandatory waste audits for significant demolition or renovation projects, regulations to require the incorporation of recycled materials, and financial incentives and penalties for non-compliance. Further, France is setting up new processing centres to boost construction materials' recycling rates, and supports research and development into new recycling technologies and processes (Diemer, 2022).

California runs and NY is developing an EPR for carpets

California has run an EPR for ten years, managed by the Carpet America Recovery Effort (CARE). Recently, they reported a significant increase in its recycling rate to 27.9% in 2021, the highest in the decade-plus history of the program (Carpet America Recovery Effort, 2022). New York State is launching the second U.S. state-mandated EPR program for carpets with the recent passing of legislation (Quinn, 2023).

Ontario's EPR

In the last decade, Ontario began shifting its municipal blue box system to EPR for household goods, shifting the responsibility of managing packaging and paper waste from municipalities to producers. This program, overseen by the Resource Productivity and Recovery Authority (RPRA), involves third-party organizations to ensure producers' compliance with waste reduction and resource recovery obligations (City of Toronto, 2022) (Ontario's Regulatory Registry, 2023).

The RPRA also oversees EPR programs for batteries, lighting, hazardous products, tires and electronics. Businesses may add charges like environmental fees to the cost of products to cover recycling expenses, with the discretion to set these fees themselves (Resource Productivity and Recovery Authority, n.d.).

EPR critiques

Implementing EPR for CRD waste introduces significant challenges due to the multi-stage lifecycle of construction products, the number of stakeholders involved, and the lifespan of products, complicating waste management and accountability processes (Yang, 2021). Reverse logistics where products must move back from the consumer to the producer can cost 5–10 times more than the original supply chain logistics. The cost and complexity of compliance can make products more expensive, potentially pricing producers out of markets where EPR laws do not exist (Guggemos & Horvath, 2003).

Stakeholder Insights: Stakeholder align with critiques

Stakeholders echo some of these criticism and highlight several challenges with EPR, including the difficulty in ascribing a producer, and the long lifespan of building materials, such as concrete, which can last 50 to 100 years, making their disposal liability deferred for decades. Furthermore, the industry-led nature of EPR means that companies often do the minimum required by regulations, resisting more stringent standards with the end result being long fights over minimum standards and not innovation.

Stakeholder Insights: Welcomes greater producer responsibility

A carpet industry stakeholder would like to see broader government support for recycling efforts, including potential stewardship programs to ensure a steady flow of materials for recycling.

Limit disposal options: Waste disposal bans

A disposal ban restricts specific materials from being landfilled or incinerated. An effective landfill ban requires supportive policies to manage the waste, strategies to prevent illegal dumping, documentation and reporting, and enforcement (Canadian Council of Ministers of the Environment [CCME], 2019). Countries like the Nordic nations, Germany, the Netherlands, and Austria have seen significant improvements in recycling rates and the adoption of more sustainable practices due to successful landfill bans and taxation schemes (Delphi Group, 2017).

Metro Vancouver ban on clean wood

Metro Vancouver imposed a waste disposal ban on clean wood in 2015. The ban is enforced through visual inspections of incoming loads, applying surcharges to loads exceeding designated thresholds of contamination. Their approach generates revenue, mostly from ICI waste haulers, with around 9% of loads in 2018 containing banned materials.

Ontario landfill bans

In 2017, Ontario put forward the Food and Organic Waste Framework, which contains an action plan and policy statement identifying how the province will address food waste within its borders. Within the Framework, Ontario states that a food and organic waste disposal ban regulation will be developed and implemented under the Environmental Protection Act, which will prohibit organic waste from ending up in disposal sites (Ministry of the Environment, Conservation and Parks, 2018).

Stakeholder Insights: Bans work well in a mature circular market

Waste management circular economy stakeholders say landfill bans are recognized as a vital part of driving material diversion from landfills with the potential to support new industries. A Vancouver-based deconstruction company said the landfill ban on clean wood and drywall have increased the cost of demolition, making his business more viable competitor in the demolition market.

However, stakeholders note that these bans often lead to materials being repurposed into low-value uses, such as fuel or mulch, which only slightly improve over landfill disposal. When materials are downcycled they fail to preserve the embodied carbon or value of the materials. Landfill bans face challenges around enforcement and preventing waste exports or illegal dumping, said a waste management policy expert. In the Vancouver context, a source-separation waste company owner said despite the landfill ban, the city transfer station will still accept clean wood but will make you pay a higher price on it.

Align financial incentives: Disposal fees

Disposal levies, added on top of tipping fees, are designed to address the social, environmental, and economic externalities of waste disposal. By raising the cost of disposal, these levies promote the use of alternatives to dumping, aiming to mitigate greenhouse gas emissions, reduce landfill space usage, and promote recycling or reuse opportunities. Landfill tipping fees are influenced by a number of factors, such as landfill size and design, environmental compliance costs, the type and volume of waste, expansion or maintenance expenses, and disposal levies (AET, 2021).

Some best practices for disposal levies include: gradually increasing rates over time, the inclusion of the levy on waste materials heading for export to keep the playing field level, and utilizing the funds collected to support existing markets without causing disruption (AET Group Inc, 2021).

Manitoba disposal levy supports municipal waste infrastructure

In Manitoba, the revenue generated from tipping fee levies is allocated through a specific formula where 80% is rebated to municipalities to support waste diversion efforts, and the remaining 20% funds provincial initiatives like the Manitoba Composts Program (AET Group Inc., 2021).

Performance-based tipping fees in Quebec

In Quebec, a portion of the funds collected from its tipping fee levy are redistributed to municipalities based on a performance based framework, creating an incentive for municipalities to improve their waste reduction and recycling systems (AET Group Inc., 2021). Quebec's levy is currently $30 a metric tonne, raising each year by $2 (S3R, 2023).

How other jurisdictions spend levy funds

In Austria, disposal levy revenues fund the rehabilitation of contaminated sites and to provide incentives for improved waste management. The UK leverages their disposal levy funds to spend on environmental programs and waste management infrastructure. Minnesota allows towns to impose fees on disposal facilities to support the general fund, but encourages levy exemptions if sites develop recycling programs (Ontario Waste Management Association, 2013).

Stakeholder insights: Economics need to change

A waste expert said that the way we handle waste now doesn't encourage recycling. Throwing everything into one bin is cheaper and easier, even if items are sorted first. Across the entire system, the project sites, the haulers, the transfer stations, the incentives point in the wrong direction. Until the problem of low costs to landfill is addressed, there is no way to change the dynamics of the current system.

Stakeholder insights: Cover all waste

A waste expert said it is important to ensure all waste materials are covered by the levy, beyond just landfills to cover waste that is exported or used in waste-to-energy facilities. Further the levy should also cover mixed CRD waste that's "recycled" but used in landfills as annual daily cover.

Stakeholder insights: Support established players & new markets

Disposal levies also need to come with education to help stakeholders change their processes, while funds should be directed to support existing players – the haulers, landfill owners, recycling companies—they need better machines and sorting capacity, said a stakeholder. Further, they said, funds can be used to stimulate new markets. For instance, the Ontario tire recycling program paid a higher price for recycled rubber to turn it into a new product, paying a premium amount for the rubber in order to facilitate the growth of the market.

Align financial incentives: Virgin material levies

Virgin material levies are taxes on the extraction of raw natural resources to encourage the use of recycled materials, slow down the extraction of raw materials (and related environmental externalities), and reduce the amount of CRD waste. The levies are usually charged when materials are first extracted, ranging from 5% to 20% of the material's original price (Canadian Council of Ministers of the Environment [CCME], 2019).

European levies in place

Sweden and the Netherlands have taxed virgin materials such as sand and gravel to encourage material recovery in construction and demolition sectors (Delphi Group, 2017).

The UK's Aggregates Levy imposes a £2 per tonne tax on sand, gravel, and rock extracted from the ground, dredged from UK waters, or imported, with a reduced rate for smaller loads. The UK allows exemptions for exports or use in certain industrial or agricultural processes (i.e., activities not for the main purpose of extracting aggregate or other minerals). Since the UK Aggregates Levy was introduced there has been a significant increase in the use of recycled aggregate, accounting for 29% of total aggregate 2020 sales and the highest proportion in Europe (Highways Magazine, 2020).

Stakeholder insight: levies can shift business processes

An embodied carbon academic said that a waste management director in the UK, explained how their aggregate company started separating and preparing pebbles and concrete from construction waste to use as recycled aggregates for resale, because there was suddenly a business case to manage their waste more carefully.

Improve CRD processes: Building codes and standards

There are engineering and building standards that can help inform building codes across the three main elements of a circular built environment – adapting and repurposing existing structures, designing new buildings for adaptability, and reusing building materials (Bansal et al., 2024).

California building code

In California, the CALGreen (California Green Building Standards Code) is the US's first building code mandating that the majority of construction projections and most demolition work recycle or recover at least 65% of non-hazardous construction and demolition debris, which is enforced using documentation when receiving an occupancy permit.

Vancouver building code

Vancouver's building code, a unique power among Canadian municipalities, requires that any construction project valued above $50,000 must sort on site, divert, and dispose of all construction waste, which is enforced by the Chief Building Official (City of Vancouver, 2014).

Open building design and material banks

Beyond waste there is a broader circular approach to create buildings that can be adapted, deconstructed, and minimize end-of-life waste. An initiative to design and build according to reversible design principles aims to ensure buildings, their systems, and materials can be repurposed, repaired, or recycled. It emphasizes the importance of designing for disassembly, and the integration of spatial, structural, and material reversibility (Durmisevic, 2019). Reversible building would also form part of a broader initiative to build future-focused materials banks, or Buildings as Material Banks, to bring order to the chaotic supply of reclaimed materials (BAMB, 2022).

Stakeholder feedback: Practical implication of BAMB on building codes

Currently Ontario's building code does not require the development of buildings for reversibility, adaptability or disassembly, leveraging the BAMB principles. An architect stakeholder outlined some specific areas that would need to be changed, such as:

- Structural connections that are easily reversible, such as pinned or bolted joints that are visible and accessible.
- Choosing high-quality materials for the structure to enhance its longevity.
- Minimizing additional layers by utilizing structure-as-finish, thus avoiding unnecessary materials like flooring over polished concrete.
- Placing all insulation outside the structure to avoid hybrid wall or roof

assemblies, using modular insulation products with reversible fasteners.

- Finding replacements to caulking and adhesives and using easy, tool-free connections and disconnections in waste plumbing

Today, they said, builders execute virtually all aspects of developments in ways that run counter to BAMB principles and doing it differently brings no cost premium and it can even be easier and cheaper than current practices.

Standards development and adoption

Engineering and technical standards underpin the building code, while providing uniform guidelines for applying materials and methods. To increase the adoption of circular-focused standards in Canada requires harmonizing definitions nationwide to eliminate confusion, integrate circular strategies like durability, design for disassembly, and material-specific lifecycle considerations into existing standards at the design, operation, alteration, and end-of-life stages. There needs to be a process to improve and harmonize technical data on new and reclaimed materials, life cycles, CRD waste, costs, and more, while enhancing education and reporting on environmental performance, and incorporating BIM and other digital tools into standards (Goodland & Walsh, 2024).

Looking more closely at what standards are needed to develop secondary materials and materials marketplaces, there is a lack of guidance for defining metrics to quantify environmental impacts from transactions. There are also insufficient specifications detailing the composition, quality, and quantity of manufacturing by-products. Standards are also needed to define salvaged materials and outline the processes of salvaging, including safety protocols, and to provide metrics and guidelines for product reuse. Further, there is a need for developing testing and evaluation methodologies for material reuse and establishing end-of-waste criteria for construction materials (Goodland & Walsh, 2024).

Green development standards

A number of Ontario municipalities have developed green development standards that require more environmentally friendly building, over and above the building code.

The City of Toronto's Toronto Green Standard, a development standard for new mid- and high-rise and city-owned developments, is managed by the planning department through site-plan approval and contains voluntary circular criteria in the upper tier of the standard. The criteria include diverting at least 75% of total construction and demolition materials and reusing structural and non-structural elements for at least 30% of the project completed floor area (City of Toronto, 2022, April).

Stakeholders insights: Wider adoption limited by legal authority

The circular criteria for waste management as part of the Toronto Green Standard can never become mandatory, because it falls outside of the powers of municipalities in Ontario to require it, a Toronto municipal official explained.

Further, stakeholders encounter barriers to wider adoption of green standards at

other municipalities because officials will say that the province regulates the building code and it stipulates that no bylaws should supersede the building code, even though there is authority through site plan control.

Voluntary green building certifications

There exists a number of voluntary, industry-managed green building standards that set requirements on energy efficiency performance, occupant health, low-carbon performance, and waste reduction. These standards help catalyze market leadership, develop industry best practices and case studies and through their adoption serve as a foundation for building codes and green standards (Goodland & Walsh, 2024). For instance, LEED waste management criteria and Passive House energy efficiency metrics were incorporated into the Toronto Green Standard, stakeholders report.

Building performance standards

In an effort to tackle emissions from the existing built environment, the City of Toronto, following other municipalities in the U.S., has started a process to achieve carbon reductions from existing buildings. Following the adoption of the Updated Net Zero Buildings Strategy in October 2023, the city implemented an emissions performance reporting by-law in December. The by-law mandates annual energy and water usage reporting for buildings larger than 929 square metres, with phased deadlines based on size. The initiative is preparing for mandatory building performance standards to be introduced in 2024, targeting energy and emissions improvements across a wide range of buildings, phased in over time (Simon, 2023).

The policy will establish emissions performance standards that progressively demand higher efficiency, and require energy audits to uncover efficiency opportunities. The City of Toronto is proposing to provide funding, technical, and permitting support, as well as fund capacity and workforce development, and advocate for support from higher levels of government (City of Toronto, 2021).

Improve CRD Processes: Reclaimed material certification

The promotion of structural element reuse needs clear guidelines for material grading and ensuring the safety of structures built from reclaimed components. Clear, standardized rules and certification processes are essential to facilitate and scale up material reuse (Hradil, 2014). Further, research and development is needed to overcome technical challenges, such as degradation and compliance with seismic and fireproof specifications (United Nations Environment Programme, 2023).

To maximize the reuse of timber, new grading rules that consider the impacts of construction, demolition, maintenance, and ageing on wood are needed to ensure the structural integrity and safety of reused timber. Furthermore, there would need to be new design principles adopted in order to adapt to the challenges with reclaimed wood. This would be established by dividing spaces to utilize shorter and thinner beams, creating smaller structural units to manage damage, incorporating a variety of lengths to eliminate waste, and more (Hradil et al., 2014).

Funding needs to be allocated to standards development organizations to work with research, material, and certification stakeholders to establish new standards for the safe reuse of building materials in both structural and non-structural applications (Bansal et al., 2024).

Improve CRD processes: Embodied carbon standards

Rules accounting for and requiring the reduction of embodied carbon emissions in new construction are just emerging and are not widespread in Canada. In 2023, Toronto passed updates to their Toronto Green Standard (TGS) v4, setting an upfront embodied carbon limit below 350 kg CO2e/m2 for city-owned buildings. This policy update also applies optionally to private buildings, but will become mandatory when TGS v5 is introduced in 2025. As well, salvaged materials are weighted to carry no embodied carbon if reused in the development (Mantle Developments, 2023).

In 2023, the Government of Canada introduced the "Standard on Embodied Carbon in Construction," mandating the disclosure and reduction of embodied carbon in major construction projects. It applies to federal projects over $10M, and aims for a 10% reduction in the global warming potential of concrete against a baseline (Mantle Developments, 2022).

Stakeholder Insights: Leverage embodied carbon standards to introduce circularity

Stakeholders say since all levels of government in Ontario have set carbon reduction targets, these policies offer a foundation or leverage point to incorporate circular economy policies. Right now incentives for the circular economy are lacking in carbon subsidies. With embodied carbon becoming a growing focus of policy makers and the broader climate-focus built environment stakeholders, it could be a good entry point to bring circularity into the policy mix, similar to how embodied carbon requirements in the UK laid the foundation for circularity audits.

Stakeholder Insights: Move on embodied carbon in procurement

Ontario could adopt the federal government's approach to low-carbon concrete by applying similar standards to other building materials to reduce embodied carbon. Further, Ontario should consider resurrecting lifecycle assessment requirements in long-term infrastructure plans, similar to plans under the previous Ontario government.

Stakeholder Insights: How to build municipal embodied carbon leadership

With the barriers to broader adoption of embodied carbon requirements at the municipal level, stakeholders recommend looking at a successful formula used in tackling operational carbon. Once municipalities integrated operational carbon considerations into their own asset management plans, they became more comfortable asking the private sector to do the same. This can also work

for embodied carbon. After municipalities learn the tools and best practices from each other, they will gain more confidence to require the private sector to meet embodied carbon requirements.

Improve CRD processes: Deconstruction standards

Deconstruction, distinct from traditional demolition, is a method that requires the dismantling of structures for the purpose of maximizing the reuse and recycling of materials.

A number of west coast municipalities in Canada and the U.S. have introduced deconstruction bylaws, leveraging differing requirements and mechanisms for enforcement and accountability.

Vancouver's Green Demolition By-law

Vancouver's Green Demolition By-law mandates a minimum of 75% of materials by weight to be reused or recycled for homes built before 1950, with the requirement increasing to 90% for character houses. Additionally, heritage-listed or pre-1910 houses must salvage at least three metric tonnes of wood. Incentives include a 50% discount on disposal fees at the landfill and a quicker permit process. A security deposit is required, which is refundable based on compliance with the green demolition conditions.

The city requires a $14,650 green demolition deposit refundable upon meeting recycling and reuse targets.

Victoria's Demolition Waste and Deconstruction By-law

Victoria's Demolition Waste and Deconstruction By-law is phased in to allow industry time to adapt, and targets single-family dwellings and duplexes constructed before 1960. A refundable fee of $19,500 encourages wood salvage for reuse, with the target amount aligned with the house's size, and fines for non-compliance (City of Victoria, 2022).

Stakeholder insights: Adopt assessment based approach and home relocation

The arbitrary nature of setting specific dates for deconstruction misses opportunities to capture homes that may be newer but still have value in deconstructing. Further, homes should also be evaluated to see if home relocation is possible, where the whole home is picked up and moved to a new location.

Stakeholder insights: performance bond underutilized tool

A stakeholder suggests the permit process as an underutilized mechanism for municipalities to enforce commitments to diversion and recycling rates during

development, citing successful examples like brownfields where performance bonds are refunded upon meeting requirements.

Strengthen diversion markets: Procurement

Purchasing departments in both public and private organizations can buy goods, services and infrastructure leveraging an environmentally friendly lens, whether it low carbon or improves environmental outcomes, such using less waste, water or emitting less pollution.

Canada's green procurement policy

The federal government's Policy on Green Procurement aims to minimize environmental impacts of government operations, promote environmental stewardship, and bolster resilience to climate change. The federal government, as mentioned above, has a procurement standard mandating the disclosure and reduction of embodied carbon in major construction projects. Further, the policy requires major suppliers to disclose their carbon emissions and set reduction targets (Government of Canada, 2022).

Circular procurement

Circular procurement is defined as the purchasing of circular products, materials, and services, by using circular procurement criteria in procurement specifications. Further it also seeks to procure from businesses using circular business models, such as product as service, supplier take-back systems, and sharing platforms. For instance, Bruynzeel Storage Systems, rather than buying lights, procured Philips' "Lighting as a service" and cut their energy costs by 73%, reduced their carbon emissions by 231 tonnes, and improved employee working conditions (United Nations Environment Program, 2018).

Barriers to procurement innovation

Public procurement is more effective in stimulating innovation in suppliers than traditional R&D subsidies, especially when combined with other instruments. Unfortunately, efforts to stimulate innovation have been met with many instances of failure. According to a detailed analysis of supplier-highlighted barriers, top roadblocks include: a lack of interaction with procurement departments, inflexible specifications that are not outcome-based, low competence among procurers, and poorly managed risk, among other barriers (Uyarra et al, 2014).

Stakeholder insights: Circular procurement struggles to gain ground with municipalities

Canada's Circular Innovation Council has built a multifaceted resource to help procurement officials purchase using a circular framework. They highlight that Canadian municipalities account for $160 billion of the $200 billion spent annually on procuring goods and services. Their resources section provides guidance on circular

policies, industry case studies, impact measurement tools, and innovative business models (Circular Innovation Council, 2020).

A stakeholder familiar with the circular procurement initiative reports high levels of frustration in its failure to gain momentum among municipalities.

Strengthen diversion markets: Linking building materials with forest management

Linking the production of building materials with carbon cycle management in forests and agricultural lands offers a path to decarbonize the construction sector, as well as mitigate the risks of forest fires and if done correctly improve land productivity through rejuvenation and responsible reforestation. By investing in technologies to transform biomass residues into construction materials like binders, bricks, panels, and structural components, this strategy taps into underutilized resources, thereby reducing emissions and enhancing carbon storage within the built environment.

Ontario launches forest industry biomass utilization strategy

The Ontario Forest Biomass Action Plan is a strategic initiative that outlines a commitment to doubling the harvest of wood, promoting innovation in biomass usage, and strengthening the circular economy. The plan sets out five key objectives, including market development, demand support, regulatory improvements, Indigenous participation, and stakeholder awareness, with specific actions under each to be implemented over the next five years. This action plan aims to leverage Ontario's forest biomass for a variety of products beyond traditional bioenergy, such as medicine, bioplastics, and construction materials, including mass timber products, composites, textiles, carbon fibre, 3D printing, biochar and carbon, along with cellulose nanocrystals and nanofibrils (Government of Ontario, 2022).

Though the Ontario strategy doesn't mention reclaimed wood, using it in mass timber products, specifically cross laminated timber proves structurally viable, though with some variations, underscoring the need for updated evaluation standards (Llana, 2022).

Strengthen diversion markets: Reuse centres

Setting up easy-to-use material exchanges, reuse centres, and stores that buy, process, fix up, and resell CRD materials is needed in order to facilitate the growth of the market and help stimulate demand and employment (Canadian Council of Ministers of the Environment [CCME], 2019) (United Nations Environment Programme, 2023) (Hradil et al., 2014).

Reuse Innovation Center in Bellingham Washington

The Reuse Innovation Center, located in Bellingham, Washington, helps facilitate circular building practices through services like building deconstruction, salvage, reclaimed materials sales, and material hauling/recycling. They sell reclaimed wood, doors, lights, and windows, and other materials they have received or harvested from

deconstruction. They offer a wishlist service to match demand with their supply of reclaimed items. Since 1994, the centre's website says they have worked on over 7,500 projects, deconstructed 1,600 buildings, diverted 150 million pounds from landfills, and created over 40 jobs (Reuse Innovation Center, 2023).

Proposed San Francisco Building Reuse Innovation Centre

The Building Resources Innovation Center (BRIC) report discusses the establishment of a dedicated centre to facilitate the collection, storage, and redistribution of salvaged and surplus building materials in San Francisco. The proposed model uses a flexible, repositionable centre that can adapt to changing community needs and provide space for material processing and storage, and a public-facing area for community engagement and educational programs. Through a regional hub-and-spoke model, partnership development to build a reuse material supply chain, policy support, and community involvement, the project sees a future where material reuse is integrated into the operations of the construction industry (StopWaste & SF Environment, 2022).

Materials highlighted

The materials chosen in the San Francisco report were based on their presence in demolition and deconstruction projects, their high potential for reuse, and their contribution to reducing construction waste. The materials include: Carpet tiles, ceiling tiles, doors, cabinetry, kitchen sinks, bathroom partitions, bathroom doors, bathroom sinks, light pendants. (StopWaste & SF Environment, 2022). Interestingly, the materials selected are not the most voluminous and ultimately would represent a fraction of the waste stream.

Digital-first approach launched

Launched by Council of the Great Lakes Region in 2021, the Ontario's Materials Marketplace, powered by material-reuse app Rheaply, is leveraging an established digital reuse marketplace, containing 2,000 North American businesses, to engage in the resale of manufacturing materials.

Stakeholder insights

Space and distribution

Stakeholders report urban locations require a distributed model that leverages underused spaces, such as below elevated roads for collection hubs, while at the same time providing large-scale operations akin to an "Ikea warehouse" to enhance the efficiency and impact of reuse initiatives.

Adaptive reuse locations

Stakeholders suggested some potential locations in Ontario that could serve as potential government-supported locations. One stakeholder suggested the decommissioned Material Recovery Facilities (MRFs) in the transition to EPR for

Ontario's bluebox system in various municipalities could be repurposed into building material reuse centres. This can serve as a model for adaptive reuse of industrial sites in mid-sized and larger cities.

In Toronto, where the MRF is not being decommissioned, stakeholders suggested unused city-owned facilities in the Portlands that are not slated for redevelopment for some time or Toronto's old Wellington Destructor. The Destructor, a now closed garbage incinerator, is stalled in its redevelopment into an adaptive space for events, community services and business development and could serve as an anchor point for a reuse depot.

Diversity, adaptability and partnership considerations

CRD waste's unpredictable supply of materials challenges the operation of reuse centres, requiring reuse hubs to maintain diverse inventories, projects and partners and flexible business models to remain sustainable. The reuse centre will, at the start and potentially for its life, depending on market fundamentals and regulation, will struggle to meet an industry requirement for a just-in-time scalable inventory (a key component of any large-scale development project).

A reuse centre operator says success requires collaborative efforts; partnerships with repair services and related entrepreneurs will help foster synergies and innovation.

Business model flexibility

Stakeholders report that the business model for reuse centres vary from for-profit, nonprofit and government supported centres. The model will depend on the circumstances in each area. Supportive policies help but reuse centres have worked with limited government support. Some have struggled to be profitable, but good management and partnerships matters. Other stakeholders say waste management has shown it can be profitable and with improved market conditions, the centre should be run as a business by entrepreneur(s) not the government.

Even in a for-profit business, establishing a non-profit organization or non-profit partnerships in order to issue a tax receipt for all materials received is a recommended approach. The appraiser should issue receipts for fair market value, not what the item is sold for, in order to help even out the differential between mechanical demolition and the more labour intensive deconstruction, according to a west-coast deconstruction company owner.

Habitat for Humanity's impact is limited by its business model

Stakeholders said there is value in having Habitat for Humanity's ReStore in the Reuse marketplace, selling salvaged building materials, furniture, appliances and finishes. Ultimately, their stores are too small to help scale a resale market. Stakeholders in the deconstruction industry say they should let the private sector lead in deconstruction. Their non-profit business model, leveraging volunteers as labourers, limits an expanded for-profit entrepreneurship in this space. Also, their tax receipts based on sale value not market value further limits the value proposition for reclaimed materials.

Material-specific innovations hold promise for productivity improvements

Quebec's brick reuse company, Brique Recyc, and a U.S. firm, The Urban Machine, highlight the potential for material-specific strategies, offering a model for handling specific materials. Their specialized processing to ensure quality, reduce labour costs, and facilitate reuse hold the potential for improved productivity and lower costs. Brique Recyc leverages a laser to clean off mortar from used bricks, aiming to be cost competitive with new bricks. Meanwhile, The Urban Machine uses robotics to remove metal (nails, screws, etc.) to make reclaimed wood more economical for reuse.

Digital first approach needed

Stakeholders in the reselling of reclaimed materials report that on-line markets have boosted their sales, one built their own digital marketplace and another leverages Facebook Marketplace to sell products since that is where the users are, they say. Some concerns were raised over some third-party apps, such as Rheaply, because of their subscription requirements and focus on large scale manufacturers.

Workshop Insights: ReHome Depot

Vision themes

The vision of a Building Resources Innovation Centre (referred to as a ReHome Depot in the workshop), based on the themes expressed by participants, should be to support innovative, affordable, circular, high-performance and regenerative buildings and a broader construction industry.

Criteria for success

The various criteria identified to ensure the ReHome Depot operates successfully span a range of criteria.

Infrastructure readiness

- Provide easy physical access to provide and receive materials
- Develop a straightforward digital platform for material identification and access.
- Create a user-friendly process for sorting and cataloguing items for sale.
- Implement tracking for materials from origin to end of life.
- Use technology to pre-identify materials for inventory.

Policy changes

- Raise landfill disposal fees.
- Modify building and demolition permits to reward materials reuse.

Market impact

- Track transaction values and sales numbers to gauge market dynamics.
- Foster new circular economy businesses and job creation in the reuse sector.
- Assess the overall impact on the market.
- Measure the flow of materials through centres.
- Track the growth of research and innovation in circularity and reuse.

Environmental impact

- Calculate the amount of materials and carbon diverted from landfills.
- Extend the usable life of materials through reuse.
- Monitor the reuse frequency of materials.
- Reduce the consumption of new, raw materials.

Social impact

- Alter the construction industry and public views on using reclaimed materials.
- Enhance the health and safety standards for recycling and reuse workers.
- Advance education initiatives focused on the benefits and methods of reuse.
- Create positive feedback loops to transform societal attitudes towards reuse.

Rehome Depot user experience

All of the groups envisioned that the reclaimed materials depot provides a comprehensive range of services focused around the reusability of construction

materials where reclaimed items are tested and certified, ensuring they meet specific standards for reuse.

Customers can access a user-friendly platform to search for materials, view detailed descriptions, and check availability. The depot manages real-time inventory, enabling efficient tracking and updating of available materials, ensuring a seamless supply chain.

The facility features upcycling spaces to transform reclaimed materials into new products, and a market offering a variety of reclaimed and upcycled goods to consumers. The depot also provides education and event spaces to experts, artisans and industrial designers to expand the knowledge of best practices in reclamation, recycling and upcycling.

An outdoor bin intake system facilitates the drop-off of reusable materials, while designated trucks and loading zone optimizes the flow of goods into and out of the depot. For specialized reclamation, there are dedicated areas separated from public facing areas, ensuring materials are processed appropriately and readied for their next life, while the front of house is not overly disturbed by the work areas.

All groups selected materials that reflect the bulk of the CRD materials that can be reclaimed and recycled including: Aggregates and concrete, bricks, wood, and metal.

Competing depot visions

There were a wide variety of visions for the ReHome Depot between groups.

Deconstruction Depot

The Deconstruction Depot group, influenced by the market realities of deconstruction, envisioned a depot that processed most materials extracted from buildings, focused on collaboration with external partners for services not directly provided, like deconstruction. The depot would also provide trucks for rental to help facilitate deliveries.

Embodied Carbon Depot

The Embodied Carbon Depot focused on embodied carbon, envisioning a depot focused on the materials carrying the highest amount of embodied carbon, due to their significant consumption in construction and impact on the environment.

Industry Unique Depot

The Industry Unique Depot group centred their depot around being unique compared to existing reclaimed material providers such as Habitat for Humanity’s Restore and to focus on materials that dominate the waste supply. They envisioned a process to move materials in and out quickly using a drive through layout.

The Experiential Depot group transformed the depot into an interactive and educational venue that was a blend between a factory and an art gallery. It would be a place where visitors can engage with the process of transforming end-of-life products into new, valuable items. The space would connect with themes of authenticity, history, and visual storytelling. Visitors would gain insight into the materials' history and the upcycling process and have the opportunity to purchase products at the end of a tour. This concept seeks to inspire a deeper appreciation for materials through a direct, human-centred experience.

Strengthen diversion markets: Innovation districts

Innovation districts are place-based strategies focused on knowledge creation and urban development, driving economic, technological and cultural growth by fostering open innovation systems and mixed-use environments. Over time, these districts have evolved from closed, single-purpose systems into integrated spaces that not only serve economic interests but also as building inclusive communities for living, learning, and collaboration (Yigitcanlar et al., 2020).

Key policy tools identified by level of government

In the development of US innovation districts, federal, state, and local governments have played complementary roles through distinct policy levers. The federal government helped provide financial support for research and development (R&D) and infrastructure development. State governments also provided direct funds but further assessed the district's economic viability, offered R&D and capital investment tax credits, and facilitated consortia between business leaders and universities. Local governments would also bring leaders together, but went further by focusing on creating attractive environments for businesses through economic planning, quality of life improvements, and financial incentives like property tax relief and exemptions (Baily & Montalbano, 2018).

Lessons learned from past innovation districts

Innovation districts have underperformed when big ideas lacked research and analysis to effectively execute, the stakeholder engagement did not capture the needs of those who would leverage the benefits of the district, the leadership was incompetent, or industry captured the process and diverted funds from the public interest (Baily & Montalbano, 2018).

Canadian federal government's supercluster initiative

In 2018, Canada announced funding close to $1 billion for five superclusters, an initiative to foster collaboration between businesses, university researchers and non-profits. The clusters were in Atlantic Canada targeting marine industries, Quebec enhancing supply chains through artificial intelligence, Ontario advancing next-generation manufacturing, the Prairies focused on plant-based proteins, and British Columbia integrating new technologies like augmented reality into health care and

resources.

With partners across the country, the clustering ended up not being a place-based physical clustering of innovators but has yielded more than 480 projects, worth over $2.16 billion, with 2,045-plus partners. With industry partners pledged to commit $1.28 billion, the supercluster initiative is showing signs of exceeding some projections, but will likely fall short of the lofty goal of increasing GDP by $50 billion. Ultimately, the innovation initiative is too early in its mandate to be judged a success or failure, according to a review (Owens, 2022).

Toronto's interrupted cluster strategy

Toronto's 2008 economic strategy targeted growth in key sectors, from aerospace to finance, but was restricted by the city's limited legislative powers and funding programs. The strategy needed and failed to secure aid from provincial and federal levels to align policies and share resources. Recommended policies for future cluster-based initiatives include developing a GTA-wide economic development agency to plan, co-ordinate and fund a multilevel governance approach to foster innovation and economic development (Galvin, 2019).

Proposed circular innovation district in Vancouver

The Green Industrial Innovation District (GrIID) project, initiated by Recycling Alternative and other local businesses in Vancouver's False Creek Flats (The Flats) area, is looking to build an eco-industrial district to foster a circular economy. The model builds on Recycling Alternative's "greenHUB", a co-location model that facilitates resource sharing among similar waste/circular businesses. The GrIID aims to transform this underutilized district into a centre of eco-industrial innovation, promoting circularity, local economic development, inclusiveness, and resilience in infrastructure, supply chain, and jobs (Bursey, 2021).

Key recommendations for GrIID's next steps

A stakeholder report identified the following key recommendations to move the project forward including implementing new city-based industrial land-use policies to protect against non-industrial encroachment, emphasizing densification within existing residential zones as an alternative. The report also recommended a shift towards a social benefits lens for municipal procurement and leasing decisions to better reflect the broader contributions of local businesses, moving beyond the sole focus on maximizing lease rates. Additionally, the GRIID needed to establish a community decision-making hub involving businesses, non-profits, and policymakers to build a collective brand and secure funding for innovation (Bursey, 2021).

Stakeholder insights: MRF closing could be a catalyst for innovation districts

The closing of MRFs across the province, as a result of the transition to a producer responsible model, could be a catalyst for the development of Circular Innovation Districts, bringing local governments, universities, businesses and key non-profits

together, reported a stakeholder.

Lack of space and increasing rent in urban markets is a concern for circular waste practitioners in Ontario, according to a number of stakeholders. If industrial lands are converted to housing and no lands are protected for industrial uses, circular businesses will struggle to operate.

Build knowledge and establish accountability: Data framework

With inconsistent and incomplete data across waste management jurisdictions, Canada needs a national waste management framework that aligns metrics, definitions and targets across regions and provinces (Scius Advisory, 2023).

Ontario needs to leverage existing IC&I and waste facility data to fill informational gaps, streamline and digitize reporting requirements for standardized data, and publicly disclose summarized waste metrics, clarifying discrepancies with Statistics Canada data when necessary (Auditor General of Ontario, 2021).

Scotland interactive waste database

Scotland maintains a comprehensive, public, interactive database that tracks waste generation, diversion, and recovery metrics by category and material type, down to facility-specific details. Scotland mandates waste collectors to report waste destinations and hold both IC&I establishments and collectors accountable for proper disposal, using mechanisms like waste transfer notes for verification (Auditor General, 2021).

Build knowledge and establish accountability: Investors and industry education

There is a need for enhanced education across the development and waste industries about the benefits and processes required to implement a more circular waste and built environment, while also emphasizing financial advantages. Educating investors at the start of a development process about circular solutions—backed by data-driven designs and engineering—is essential. This approach should be grounded in clear guidance, technical solutions from established standards, and shared definitions. Additionally, case studies can bolster confidence throughout the industry (Goodland & Walsh, 2024).

Stakeholder insights: Investor education is a complex web

An embodied carbon expert working for a development firm related that he has been surprised by how much of his work involves working with investors about the importance of lifecycle analysis, carbon reduction through design, and circularity in the context of sustainable architecture and development. They highlight the complex relationship between architects, developers, and investors, where from project-to-project, the work involves discussing, negotiating and educating others to adopt specific low carbon or circular practices all within the context of ensuring profitability and investment returns.

Build knowledge and establish accountability: Government

Stakeholder insights: Municipal leadership is key for unlocking circular innovation

Municipalities have the most direct point of interaction with the development industry (as well as in municipal solid waste, but less in ICI waste). In BC (and to a certain extent in Ontario), municipalities are leading the way when it comes to adopting circular practices, most pronounced in the adoption of deconstruction bylaws, landfill bans of CRD materials, and adopting circular requirements in building codes and green building standards, report stakeholders.

Stakeholder insights: Municipalities need support for innovation

Stakeholders relay that for municipalities to foster innovation, there is a need for funding mechanisms that allow for experimentation and innovation, and for fostering robust partnerships with educational institutions, innovation centres, and economic development agencies.

Stakeholder insights: BC Step Code a model in municipal co-ordination

In order to foster circular innovation at the municipal level, stakeholders recommend emulating a process used in British Columbia to help facilitate the introduction of the B.C. Energy Step Code. This strategy would entail establishing multi-municipality stakeholder groups, bringing together municipalities and industry stakeholders to collaborate on a shared roadmap, which can reduce the confusion and industry resistance that can arise when each municipality introduces disparate regulations. The strategy would include a comprehensive education and outreach program, focused on guides, workshops, and case studies, as well as sending industry a clear signal of the long-term policy direction.

Stakeholder insights: Provincial leadership needed to support municipal waste efforts

The province can play a role in ensuring that there are circular standards that all municipalities follow and implement simultaneously to build a level playing field. Further, since municipal governments don’t oversee ICI waste, they need provincial support or powers granted by the provincial government to affect change. As part of Toronto’s exploration into expanding its circular strategies, officials relay that they may lack legal authority to pursue some strategies and have had limited success over the years getting new powers from the province.

Stakeholder insights: Create a Minister of Construction

A stakeholder points out that the Canadian construction industry, a $250 billion market employing one in 13 Canadians, is not overseen at both the federal and provincial levels as a whole. Governance of the industry is fragmented across various sectors, such as housing, infrastructure or transportation, and this contributes to its underestimation by policymakers, and challenges in advocating for necessary investments and changes. As a result, there needs to be a “Minister of Construction.”

Discussion

The research provides a systemic analysis of the circular use of CRD waste within Ontario's built environment, aiming to inform provincial policy to enhance circularity. Key findings reveal that Ontario's construction industry, despite its economic significance, has substantial waste management challenges, achieving only a fraction of recycling or reuse rates. Meanwhile, provincial regulators, operating with imprecise data on waste composition, have enabled a system with high but unmet diversion targets, while facing an impending landfill shortage and high levels of carbon pollution.

The study highlights how a circular built environment in Ontario aims to adapt existing structures and design new buildings for adaptability and foster material reuse. Further, it offers substantial benefits like carbon reduction and biodiversity improvement, and economic gains through material cost savings, job creation, and GDP growth, but significant barriers hinder their adoption. These include regulatory and policy gaps, insufficient standards, and lack of support for reclaimed materials, compounded by operational inefficiencies and cultural resistance against reused materials. To enhance circularity, provincial decision makers need to implement a range of policies focused on establishing accountability, aligning economic incentives, improving waste management processes, supporting infrastructure development, and encouraging municipal leadership and industry engagement in an integrated approach to waste reduction and reuse.

Interpretation of findings

The findings from this research highlights a significant underutilization of resources, a systemic inefficiency in current development and waste management practices. While many policy interventions exist their implementation and enforcement are significantly lacking. By improving waste management processes and encouraging the reuse and recycling of materials, Ontario can reduce landfill use, lower carbon emissions of the construction sector, and foster new circular economic opportunities. Though Ontario is behind in the global race to adopt circular practices, the research findings align with global trends, where challenges such as labour costs, lack of standardization, and business culture hinder the adoption of circular materials.

The findings extend existing literature by providing a place-based analysis of the barriers and opportunities specific to Ontario, offering targeted insights that address the unique challenges faced by Ontario.

This study recommends policies to shift the financial incentives at the provincial level, making waste more expensive, while focusing on targeted measures on the most voluminous CRD waste materials to help improve diversion outcomes. This effort will help mitigate economic and market challenges, such as the low cost to dump CRD waste, subsidies for virgin materials, and the limited market for reclaimed materials. This study also recommends boosting the supportive infrastructure for reclaimed CRD materials, helping to mitigate industry and operational barriers, such as a lack of circular infrastructure and supply chain challenges. Supportive infrastructure will also help mitigate constraints related to market competitiveness and perceptions that reclaimed materials are of a lesser quality. Finally, this study will recommend unlocking municipal leadership, mitigating a host of regulatory, economic, operational and cultural barriers, such as poor data, unclear definitions and limited technical standards, a lack of municipal capacity, slow adoption of embodied carbon requirements, limited market for reclaimed materials, status quo bias and more.

Contribution to the field

The findings from this research contribute to the field of waste management and circular economy practices by filling a knowledge gap regarding the implementation of circular waste and material policies at a provincial level. The findings can be directly applied to the drafting of policies to increase the market value of reclaimed

materials and support infrastructure for reclamation and recycling. Furthermore, these results have implications for the construction industry and climate policy communities by suggesting that integrating circular economy practices can lead to substantial cost savings, reduced environmental impact, and enhanced social acceptance. The research could guide architects, builders, planners and decision makers in adopting more circular practices that align with circular economy principles, potentially transforming the built environment.

Limitations

While the study provides insights into the circular CRD waste management system in Ontario, it has several limitations. Firstly, the reliance on semi-structured interviews and participatory design workshops, although valuable for gathering qualitative insights, may introduce subjectivity to the findings. The perspectives shared by stakeholders are influenced by their personal experiences and may not represent the broader industry or regulatory environment.

For instance, despite a recent focus in expanding EPR at the provincial level, the stakeholder and secondary research findings point to a difficult path forward for EPR for CRD waste. The complex lifecycle and long lifespan of building materials, and regulatory compliance issues limit its effectiveness. Further, despite the market shaping force for innovation that public procurement can provide new industries, this study does not recommended as a lead solution. The slow adoption of innovative procurement processes and well documented barriers to change, limit its practical ability to foster a more circular system. Finally, this study does not recommend making province-wide changes despite the province's key role in shaping the planning, waste and buildings frameworks. This is as a result of the early stage of circularity in Ontario (e.g., a lack of infrastructure and markets, etc.), the importance municipalities can play in fostering innovation, and the documented barriers they currently enable.

Due to the broad systemic nature of the research, some barriers and opportunities were more deeply analysed than others, or featured more insights from a broader range of stakeholders. For instance, one key recommendation on building the infrastructure related to support secondary markets, specifically a reclaimed building reuse centre, was the focus of a workshop involving some two dozen stakeholders. Meanwhile, another recommendation for innovation districts was generated from a key insight from a single stakeholder.

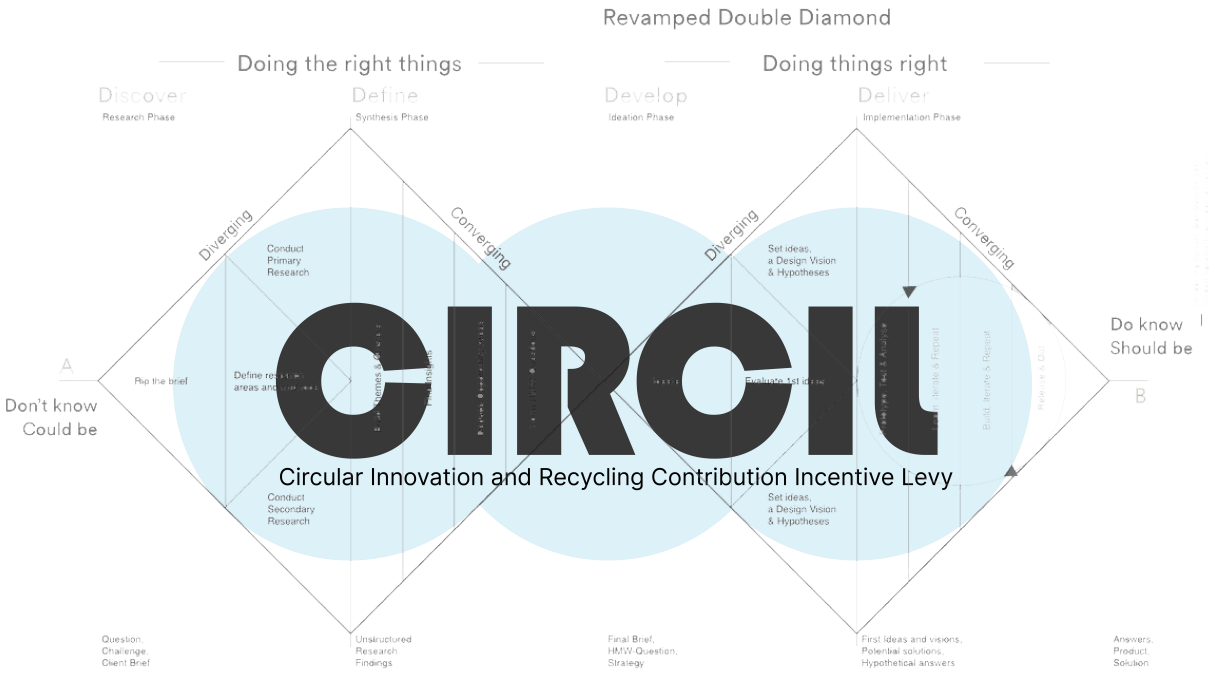
To address these limitations, future research could expand the scope of research to include quantitative data analysis to complement the qualitative insights. Moreover, engaging a broader range of stakeholders in future studies or in efforts to implement any of the recommendations could also help mitigate the bias inherent in a smaller, more focused participant research project.

RECOMMENDATIONS

The following recommendations attempt to help increase diversion and foster a more circular CRD waste and materials system in Ontario, while being grounded in the policy levers of today. The first set of solutions help increase the cost of waste through a revenue-neutral disposal level on ICI waste, followed by actions to increase the cost of virgin aggregates and limit the disposal options for clean wood.

The ReHome Depots initiative envisions a province-wide network of building materials reuse centres in cities with populations over 200,000, serving as central hubs where consumers and businesses can donate, purchase, and learn about repurposing CRD materials. The Rehome Depot would be centred around a cluster of circular businesses in an Circular Innovation District to help facilitate an expanded circular ecosystem of like-minded and synergistic businesses.

Finally, these efforts would be supported by a new government agency supporting municipal ground-level innovation. This agency would aim to increase circularity in the built environment by addressing a lack of unified standards, sufficient data, and municipal legal authority with the goal of integrating circularity into new and existing buildings through green development and building performance standards.



Revenue-neutral ICI disposal levy

Implement a $10 Circular Innovation and Recycling Contribution Incentive Levy (CIRCIL) on ICI waste that gradually increases over time to allow businesses to adjust. The rate will be raised to $5 per year starting in 2026 and reaching $60 by 2036.

- **Cover all ICI Waste:** Ensure the levy applies to all forms of ICI waste, including those destined for transfer stations, landfills, export, or waste-to-energy facilities.
- **Performance-Based Incentives**: Integrate a performance-based component where businesses that demonstrate significant waste reduction, reclaimed or recycling efforts are rebated a percentage of the levy, through certified waste management reports.
- **Reinvestment of Levy Funds**: Allocate a significant portion of the revenues generated from the levy back into the waste management infrastructure, including using grants and government-backed loans for existing waste management practitioners and new innovative businesses to:
    - achieve the highest and best use of waste materials,

- improve sorting and diversion,
- adopt new processes and technology, and
- foster synergistic partnerships between firms (where the use of under-valued resources is turned into new products).

- **Stimulate Secondary Material Markets**: Part of the CIRCIL funds should be directed towards stimulating the market for recycled and reused materials, such as premium purchasing agreements, where public entities pay a higher price for collecting certain materials and products made from recycled materials to encourage market growth.
- **Waste Exemptions & Local Adjustments:** Understand and Implement measures to ease or exempt the levy for some businesses and situations, such as for emergencies or Indigenous or charitable organizations, or for regional adjustments for the North to reflect local economic conditions, waste management capacities, and environmental priorities.
- **Transparent Reporting and Accountability**: Establish clear reporting requirements for collecting and using the levy funds to ensure transparency and accountability to easily track how funds are being reinvested.
- **Educational and Awareness Campaigns:** The disposal levy will be introduced accompanied by comprehensive educational campaigns aimed at businesses to highlight the importance of source separation, waste reduction, and recycling.

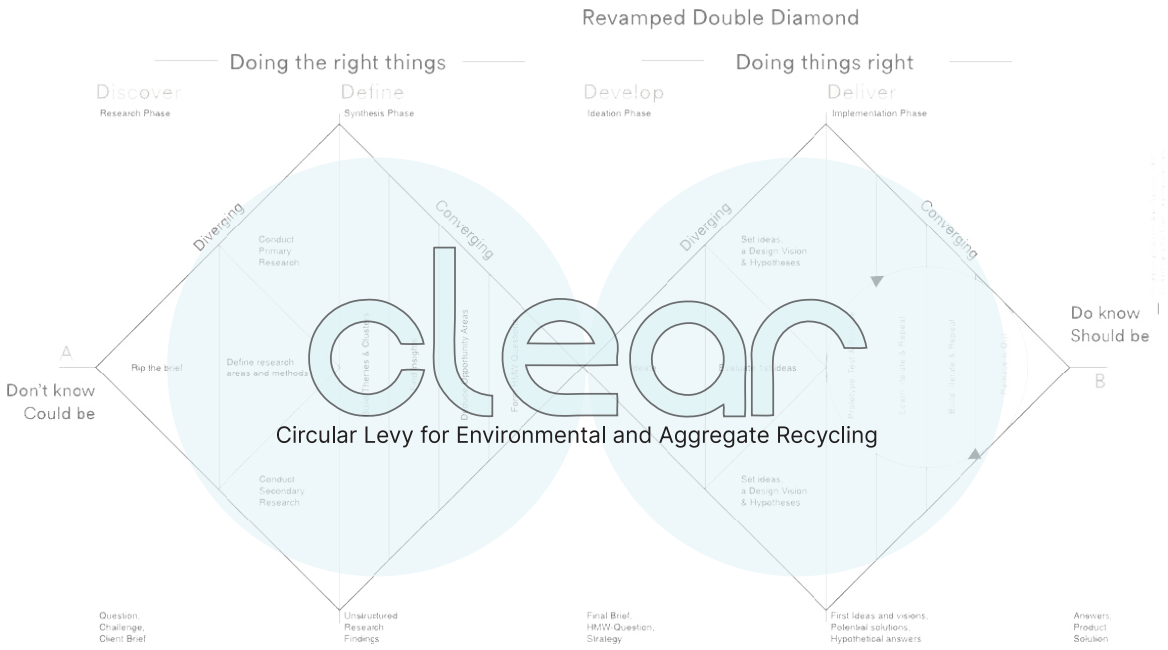
Revenue implications

Here is a chart to get a sense of the revenue generated: it displays the projected revenue generated from the ICI waste levy (60% of 13.5 million tonnes) and CRD waste (9% of 13.5 million total) from 2026 to 2036. The starting levy is $10, increasing by $5 each year. The chart assumes a 5% annual decline in waste generation starting in 2027, representing a 43% drop in waste by 2036.

Figure 2: Breakdown of potential revenue from ICI waste levy

Year	Total Waste (Million Tonnes)	ICI Waste (Million Tonnes)	CRD Waste (Million Tonnes)	Levy ($/ tonne)	Revenue from ICI ($ Million)	Revenue from CRD ($ Million)
2026	13.500	8.100	1.215	10	81.00	12.15
2027	12.184	7.310	1.097	15	109.65	16.45
2028	11.575	6.945	1.042	20	138.89	20.83
2029	10.996	6.598	0.990	25	164.94	24.74
2030	10.446	6.268	0.940	30	188.03	28.20
2031	9.924	5.954	0.893	35	208.40	31.26
2032	9.428	5.657	0.848	40	226.26	33.94
2033	8.956	5.374	0.806	45	241.82	36.27
2034	8.508	5.105	0.766	50	255.25	38.29
2035	8.083	4.850	0.727	55	266.74	40.01
2036	7.679	4.607	0.691	60	276.44	41.47

With the ICI sector representing 1.6 million businesses in Ontario and the construction industry contributing $57 billion to Ontario's GDP and Ontario waste management sector generating $2.79 billion in GDP, the revenue raised is not enough on its own to shift to a more circular waste and materials system and would need to matched or expanded upon by other regulations and support.



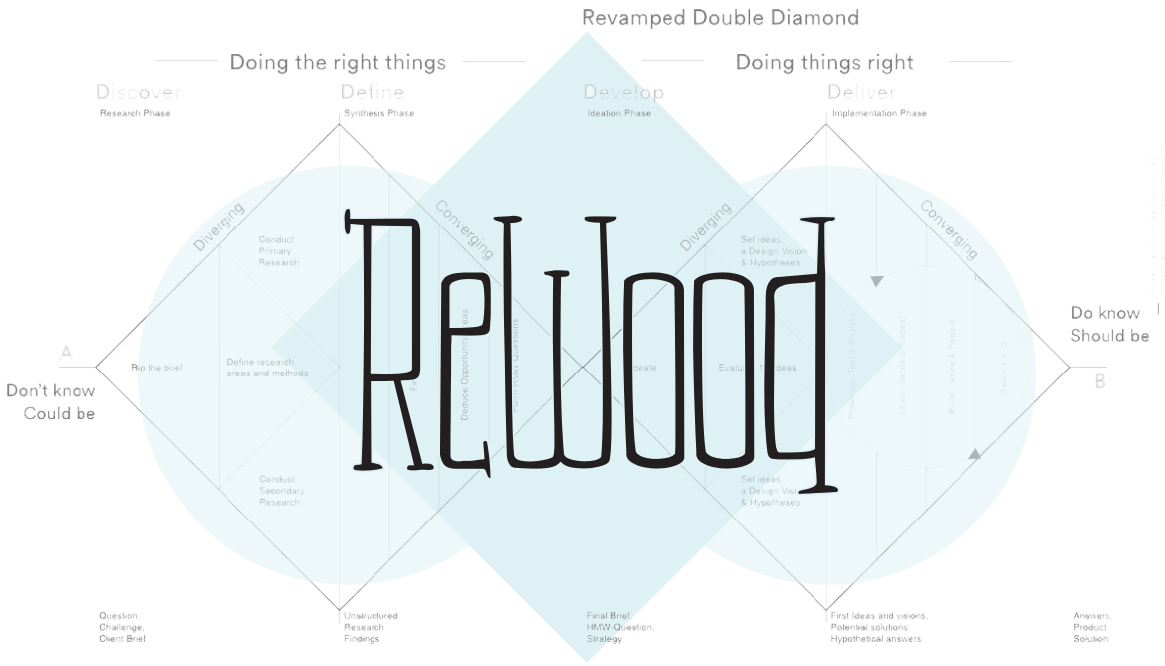
Revenue-neutral aggregates virgin material levy

In 2026, impose a $2.50 per tonne virgin material levy on aggregates – rock, sand and gravel – produced in Ontario to encourage the use of recycled materials called the Circular Levy for Environmental and Aggregate Recycling (CLEAR). Increase the levy each year until it reaches $5 in year four (an increase in $0.83 per tonne each year).

- **Reinvest Levy Funds**: Use revenue generated from the levy to fund similar initiatives as the CIRCIL fee (e.g. waste management infrastructure and secondary markets) as well as research and standards development for using reclaimed aggregates in new construction, and the hiring of more enforcement officers to ensure the industry improves their record of compliance and accurately pays their levy fees.
- **Provide Exemptions:** Provide exemptions for aggregates produced for export and as a result of unrelated activities, such as industrial processes. Further, consider partial performance-based reductions through certified diversion activities by aggregate companies to help foster integrated supply chains.
- **Update Specifications:** Update provincial recycled aggregate technical specifications for roads and buildings, require its usage in procurement and work to harmonize standards across municipalities to encourage wider adoption of recycled aggregates.

Revenue implications

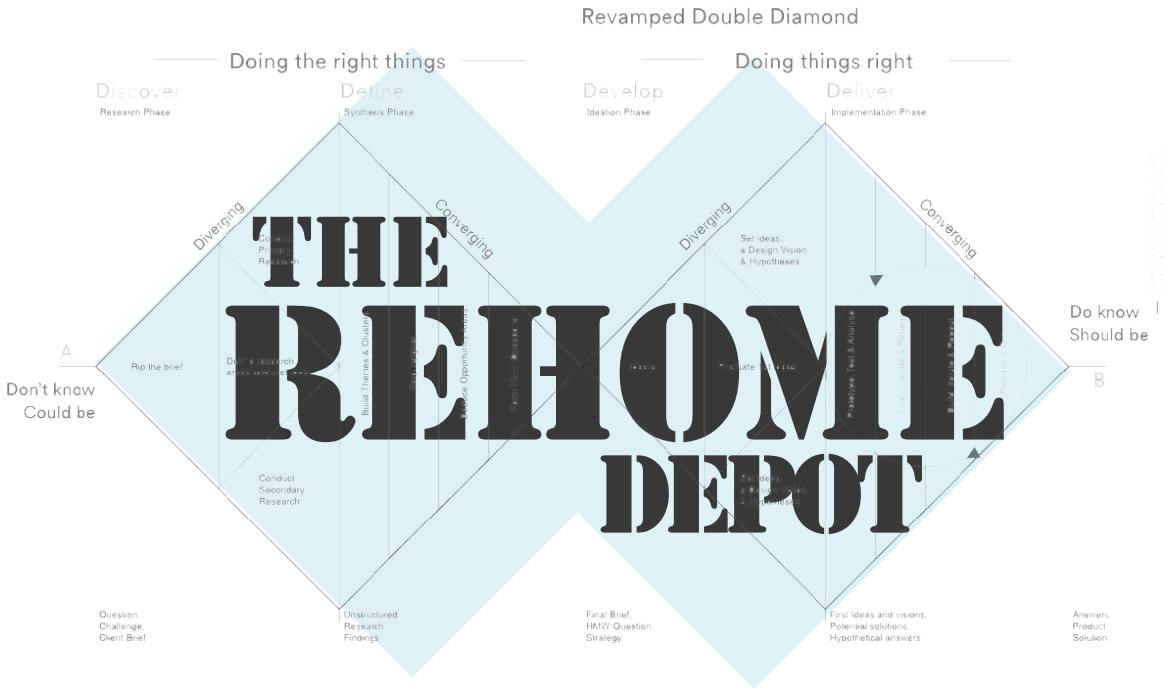
Assuming about 150 million tonnes of aggregates produced each year would raise $375 million starting at $2.50 a tonne, rising to $750 at $5 a tonne.



Landfill ban on clean wood

In 2029, after some time preparing waste management infrastructure, implement a clean wood disposal ban regulation under the Environmental Protection Act, called ReWood (Reclaimed Wood), to prohibit clean wood from being landfilled, exported or incinerated to help improve diversion rates, and foster a broader circular ecosystem supporting the reclaimed wood industry.

- **Understand Wood Waste Dynamics:** In 2026, conduct studies to understand the material flow of clean wood and the market potential for reclaimed and recycled clean wood in Ontario.
- **Build Supportive Infrastructure**: In 2026, to ensure the success of landfill bans, understand and invest in the physical infrastructure required to manage the diverted materials, such as supporting existing transfer stations and landfills to build the capacity to process the materials and provide paid space for on-site separation (recognizing the logistical complexities of source separation in some situations).
- **Foster Greater Re-use**: Since landfill bans are more effective in mature circular markets, an early focus needs to be reducing the downcycling of materials into low-value uses and building up secondary markets, including incorporating waste wood streams into the Ontario Forest Biomass Action Plan and through premium purchasing agreements to pay a higher price for the collection of clean materials and products made from recycled and reclaimed clean wood.
    - **Address Structural Viability Concerns**: Address the structural viability concerns of using reclaimed wood in buildings and as part of cross-laminated timber (and other bio-based building products) through investment in technical research and standards development.
- **Build Enforcement Capabilities**: Invest in supportive infrastructure to combat illegal dumping and ensure there are mechanisms for documentation, reporting, and enforcement of the ban.



Building Materials Reuse Innovation Centres

Develop a province-wide network of Building Materials Reuse Innovation Centres called ReHome Depots, in cities over the size of 200,000 inhabitants. The depots would be a "one-stop shop" central hub for consumers and businesses to donate, purchase, and learn about repurposing CRD materials.

- **Conduct Preparatory Studies:** in 2026, conduct studies for the Rehome Depot such as market demand analysis, feasibility studies, environmental assessments, supply chain logistics, stakeholder engagement surveys, site selection and planning, regulatory compliance reviews, technology and process evaluations, and financial modelling.
- **Select Pilot Locations**: Select three pilot locations for development in the three largest population centres: Toronto, Ottawa and Hamilton.
- **Foster Partnerships:** Build partnerships among government, businesses, non-profits, and the community to develop a robust network supporting material reuse.
- **Target Surplus Locations:** Consider the adaptive reuse of decommissioned Material Recovery Facilities (MRFs) and other suitable city or provincial-owned properties as locations for ReHome Depot facilities.
- **Launch Pilot Locations**: In 2027, launch pilot locations and learn and adjust and begin preparatory consultations for remaining locations.

Business model

- **Use a Hub-and-Spoke Model**: Adopt a distributed model for depots in urban areas, leveraging underutilized spaces for collection hubs, while ensuring sufficient scale for operations.

- **Implement Adaptive Business Model:** Explore various business models for reuse centres, including for-profit, non-profit, and government-supported, tailoring the approach to local circumstances and diverse operational models to start, with a plan to move towards a for-profit system as the market becomes more established over time.
    - A charitable organization or partnership could issue receipts for fair market value to help improve the economics of the reclaimed materials market.

Services

- **Provide Complimentary Services**: Provide space in the depots or partner with businesses to provide deconstruction, reuse, and repair services (or develop the capacity to provide these services) to foster synergies and innovation.

Online

- **Digital Platform Development**: Create an open-source digital platform that allows customers to easily search for available reclaimed materials, view detailed descriptions, check real-time availability and integrates with existing marketplace ecosystems
- **Inventory Management System**: Implement an inventory management system that updates material availability in real-time, ensuring a seamless supply chain and customer experience.
- **Embodied Carbon Reports**: Provide embodied carbon reports, certifying the amount of carbon diverted from reclaimed materials

Outdoor

- **Outdoor Bin System**: Install an outdoor bin intake system for the easy drop-off of reusable materials by the public and businesses.
- **Truck and Loading Zones**: Designate specific areas for trucks and loading to optimize the flow of goods into and out of the depot, ensuring minimal disruption to depot operations and customer experience. Explore the option for renting trucks for material salvage.

Back of House

- **Reclamation Areas**: Allocate separate areas for processing reclaimed materials, away from customer-facing sections of the depot to maintain a clean and organized front-of-house environment.
    - Procure or partner with innovative processing technology companies, such as those demonstrated by Brique Recyc and The Urban Machine, to streamline the preparation of materials for reuse and make them more economically viable.

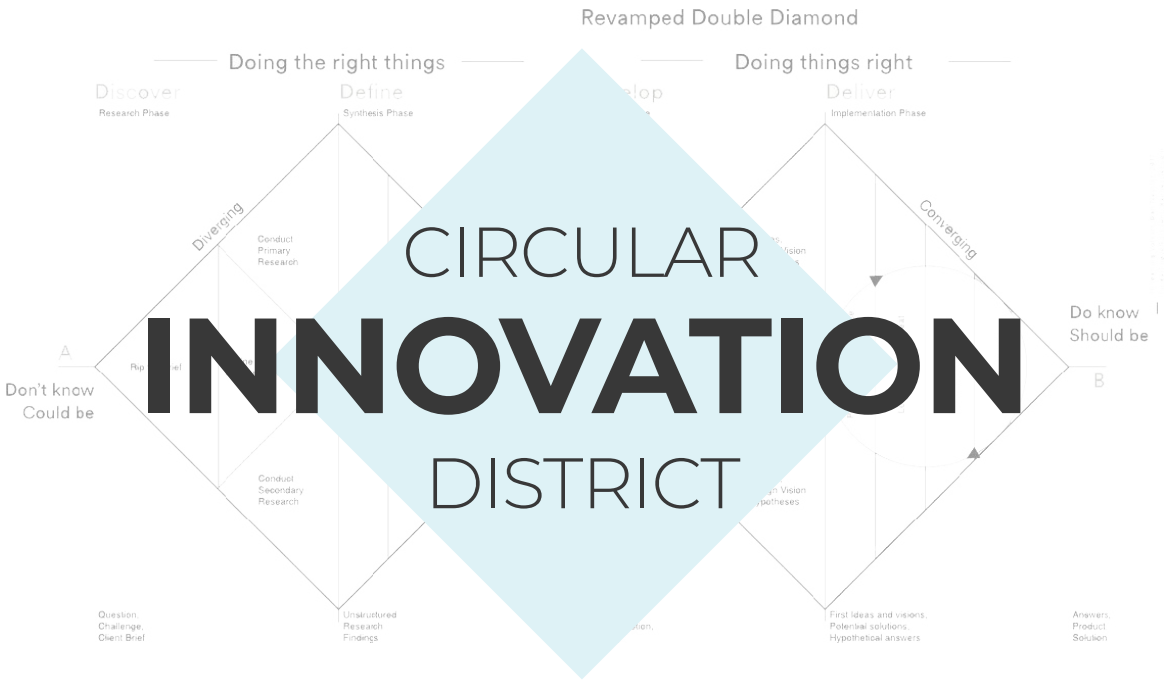
- **Deliver Testing and Certification**: Develop, fund and implement a set of standards and processes for testing and certifying reclaimed construction materials to ensure they are safe and suitable for reuse and issue certificates that verify their compliance with reuse standards.

Education, events, market and work spaces

- **Dedicate Space for Upcycling**: Designate and equip specific areas within the depot for upcycling activities to facilitate the transformation of reclaimed materials into new products.
- **Provide Retail Space:** Provide a market space within the depot for the sale of upcycled goods and unique reclaimed materials to consumers (while provide sales of traditional building materials in a less front-facing area).
- **Deliver Educational Programs**: Develop and offer educational programs and workshops focused on best practices in reclamation, recycling, and upcycling that targets a wide audience including experts, artisans, and the general public to help foster a culture of circular economy practices.
- **Event Space:** Build designated spaces for events, exhibitions, and demonstrations that promote circular practices and community engagement in material reuse.
- **Leverage Experiential Storytelling**: Support the integration of experiential storytelling spaces within recycling and reuse facilities, transforming them into interactive and educational venues where visitors can engage with the history and process of transforming end-of-life products into new, valuable items, with an exit through the gift shop to increase sales.

Reclaimed CRD materials

- **Diversity in Supply:** Ensure depots maintain diverse inventories to adapt to the unpredictable supply of CRD waste and variable market conditions.
- **Material Selection**: Focus on the collection, processing, and sale of key CRD materials such as aggregates and concrete, bricks, wood, and metal, reflecting the majority of materials that are available in the waste stream and have high levels of embodied carbon, while being open to materials that yield the highest return on the resale market.



Circular Innovation District

Develop Circular Innovation Districts, anchored with ReHome Depots, to promote former industrial lands as integrated multi-use circular innovation districts, ensuring spaces are dedicated to circular economy initiatives to prevent displacement by non-industrial development.

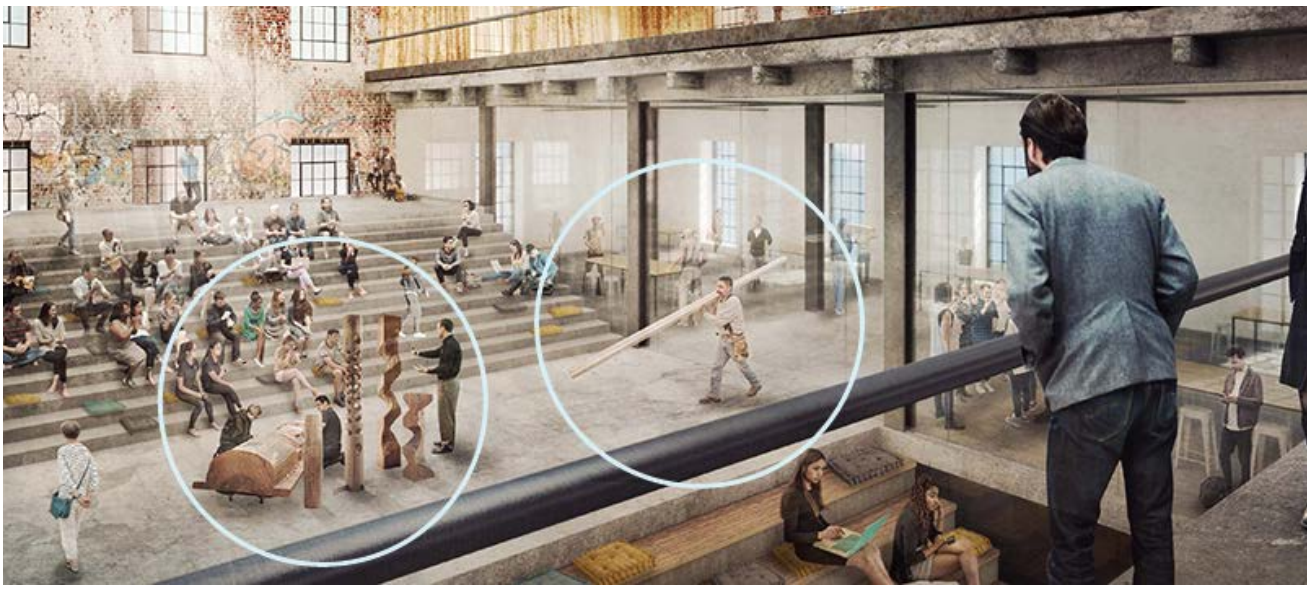
- **Conduct Research and Engagement:** In 2026, conduct research and analysis, engaging a wide range of stakeholders, to support the circular innovation district vision, meet the community's needs, assess economic viability, and leverage potential benefits effectively.
- **Target Former Industrial Lands:** Enact policies to protect target industrial lands for reuse activities, ensuring spaces are dedicated to circular economy initiatives to prevent displacement by non-industrial development, while making space for densification within existing zones.
    - Foster collaboration across sectors, recognizing that physical proximity in clustering is not the only model for innovation. Successful projects can also stem from region-wide partnerships, but strong place-based initiatives can create greater awareness of a sustainable material ethic, lacking in today's economy.
    - Recognize the potential catalytic role the closing Material Recovery Facilities (MRFs) can have in spurring the development of Circular Innovation Districts.
- **Provincial Leadership**: Provide direct funding, research and development grants and loans and capital investment tax credits, and facilitate consortia among business leaders, non-profits and academic institutions.
- **Seek Federal Support:** Secure federal funding for research and development and infrastructure development to catalyze innovation district initiatives.

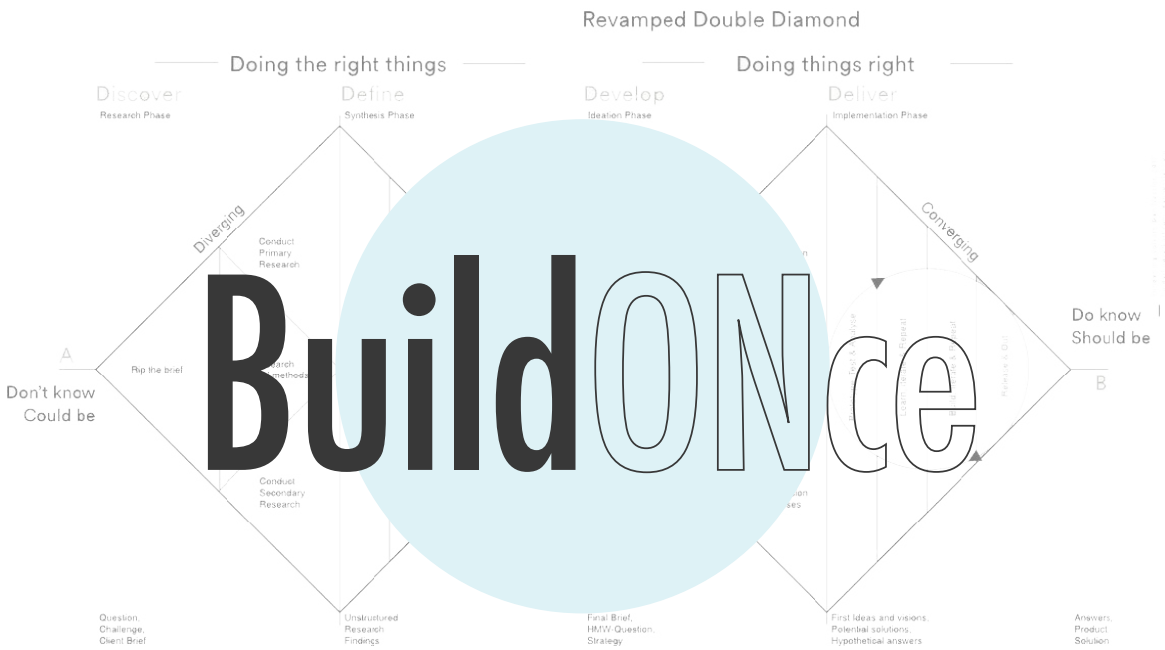
- **Local Government Support**: Partner with local municipalities to create an attractive business environment through economic planning, quality of life improvements, and financial incentives such as property tax relief and exemptions.
    - Recognize the limitations imposed by municipal legislative powers and evaluate providing more powers to help facilitate local economic development.
    - Consider establishing a wider economic development agency for large population centres to coordinate and fund innovation and economic development efforts.
    - Evaluate the establishment of a community decision-making hub in proposed districts that includes businesses, non-profit organizations, and policymakers to foster a collective brand and secure funding for innovation efforts.

Proposed Ontario's first Circular Innovation District

Toronto has the potential to take an existing nexus of circular place-based initiatives and build a ReHome Depot and designate the area around it a Circular Innovation District. In South Niagara, a ReHome Depot could be located in the old Wellington Destructor, a redevelopment currently stalled but slotted for redevelopment as a new arts, culture and community hub. Next door at 2 Tecumseth, Tas Impact is building a mixed-use development, leveraging 62% of reclaimed building materials from an on-site decommissioned abattoir (Tas Impact, 2023). Down the road is Stackt Market, built using repurposed shipping containers and just south is the Bentway, a public place repurposing unused space under the Gardiner Expressway. Taken together, these pieces could form a story about circularity and with some vision and political leadership, could be a catalyst for Ontario's first Circular Innovation District.

The architectural renderings of the Destructor redevelopment site have the seeds of the ReHome Depot, as seen in the below image from the Destructor's promotional website that contain people working with wood.





Ground-level integrated innovation

Municipal governments are on the front-line of the development industry and are well placed to help foster a more circular waste industry, but lack unified definitions, standards, data, bylaws, tools, capacity and legal authority to affect change.

Compounding this effort are demands to decarbonize and bolster the built environment's resilience while building more homes faster to help mitigate the impact of the housing crisis.

In an effort to create a level field across municipalities, foster municipal leadership in progressive jurisdictions, and provide certainty to industry, the province should set a clear framework to establish step standards for new builds and retrofits that incorporate requirements to build, operate, and retrofit high-performing, low embodied carbon, circular, resilient buildings. Further, what works in North Bay is different for Toronto and therefore, requirements and phases should reflect this variability while maintaining certainty for builders across the province. This is a radical change for the private sector to significantly improve their practices and it will require a significant fiscal response from the province to support the transition. Further it will require upskilling and new skilled trades, which is currently in short supply and has no easy fix.

The Ontario Building Code would continue to be harmonized at the federal level, following the model code's timeline on operational, embodied carbon, resilience and retrofitting existing building, but this agency would be tasked with going beyond the minimum to make Ontario a leader in transforming the built environment. Their leadership can help inform the building code process as well.

In order to facilitate this significant task, the province needs to in 2026:

- **Create Build ONce Agency**: Create a new public agency called Build ONce (Build Ontario Circular Economy and Build Once as in get housing right, once and for all) to integrate decarbonization, resilience, and circular outcomes into the built environment, while harmonizing data and standards across municipalities.

- **Harmonize and Digitize Waste Data:** Create a provincial waste management framework that aligns metrics, definitions and targets across regions and provinces and create an interactive database that tracks waste generation, diversion, and recovery metrics by category and material type, down to facility-specific details.
- **Develop Technical Standards**: Fund the research, development, updating, testing and implementation of circular strategies like durability, design for disassembly, and material-specific lifecycle considerations into existing technical standards at the design, construction, operation, alteration and end-of-life stages.
    - Develop a province-wide solution to develop a simplified certification process of reclaimed building materials, starting with wood and aggregates.
    - Update specifications for the use of recycled aggregates and asphalt in roads works (and similar projects), and harmonize across municipalities.
    - Research test and update specifications for reclaimed wood in new advanced biomass building products.
    - Explore other uses of reclaimed materials and support provincial and municipal procurement initiatives.
- **Convene Expert Tables**: Convene development and waste management professionals, non-profit organizations and local governments to help shape the development of Green Development Standards, Building Performance Standards and Deconstruction Standards.
- **Grant Legal Authority**: Grant municipalities the legal authority to require specifications within the established step framework.
- **Cut Fees and Taxes:** Fund municipalities the differential for cutting development fees and taxes drastically in line with the step standards, while also progressively cutting provincial fees and taxes – the higher the standard, the lower the fees and taxes, the bigger the funding from the province.

In 2027-28, after laying the groundwork, the province would need to:

- **Develop Green Development Standards**: Develop Step Green Development Standards with the goal of moving the industry to high-performance, resilient, low-embodied carbon, and circular buildings for all city-owned and new Part 3 Buildings (buildings over 600 m2 and above 3 stories), phasing in the expansion from larger buildings to smaller Part 3 Buildings over time.
    - **Fund Municipal Leadership**: Incentivize and support municipalities to implement the top tier on city-owned buildings in order to understand compliance and market considerations in their development and asset plans.
    - **Phase in Requirements**: After embodied carbon requirements, phase in circularity requirements. Start by requiring waste separation and diversion at the base tier, adding deconstruction in the mid-tier, and finishing in the top tier with design for disassembly and adaptability.

- **Develop Deconstruction Standards:** Develop Step Deconstruction Standards for Part 3 Buildings (Less than 600 m2 with fewer than 3 stories) as Part 9 buildings are covered in Green Development Standards.
    - **Phase in Requirements**: Set steps by age with heritage homes at the base, and the age of the homes increasing over the steps with the top tier including an assessment-based model (where all homes are assessed) and home relocation is required for some assessed homes.
    - **Tiered Refunds:** Develop a tiered deconstruction permit that delivers a full refund for relocation and tiered from there based on materials salvaged. Build a favourable tax incentive for donated materials and relocated homes.
- **Develop Supporting Resources:** Develop supporting tools, resources, guides, events and stakeholder engagement to facilitate the development, refinement and implementation of the standards.
    - Fund training for builders, deconstruction experts, and certifiers to be able to deliver to these requirements effectively.

In 2028-29, the province would need to:

- **Develop Step Building Performance Standards**: Develop province-wide step building performance standards that move the existing building stock towards high-performance and resilient buildings that are retrofitted using low-embodied carbon and circular materials, while waste is diverted.
    - **Establish Emissions Performance Standards:** Implement standards that require buildings to progressively improve energy efficiency, reduce embodied carbon, and increase circularity tailored to accommodate sectors, building types and incomes.
    - **Provide Technical Suppor**t: Provide resources, support services, education and zero-interest financing for retrofits projects and building owners.
    - **Streamline Permitting Processes**: Support simplifying the procedures for obtaining necessary permits and approvals for projects.

CONCLUSION

Ontario's built environment, despite its economic significance, is limited by a waste management (and carbon pollution) challenge, with a mere fraction of CRD waste being recycled or reused. This situation is rooted in regulatory, policy, economic, and operational barriers and a lack of data on CRD waste composition and disposal. However, this paper proposes a shift towards a more circular CRD waste and materials system as a viable solution, proposing provincial policies to limit disposal options, align financial incentives, improve CRD processes, and boost capacity and education. Through an integrated approach that includes increasing the market value of circular materials, supporting the development of reclamation and reuse infrastructure, and enabling innovation at the municipal level, Ontario can overcome these challenges. The recommendations aim to catalyze a systemic transformation towards more sustainable and circular waste management and development practices, starting in 2026 and moving into the future.

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