Circular Solutions for CRD Waste in Toronto

HALEY ANDERSON

Ryerson University

Circular Solutions for CRD* Waste in Toronto

HALEY ANDERSON

Keywords:
circular economy, construction renovation and demolition waste, waste management, systems thinking, systems change, sustainable growth

****CONSTRUCTION, RENOVATION, AND DEMOLITION WASTE*** (CRD) in the city of Toronto goes largely unmonitored and unregulated. As the city rapidly continues growing and changing more as the COVID-19 Pandemic has impacted the way people use and need space, there will certainly be no slowing of the amount of CRD waste produced. With a changing market, population, and changing individual needs, many opt to renovate or demolish and start new, all the while creating waste. This waste is often overlooked in conversations of green building and sustainable growth. In an effort to understand the problem, this project examines the current policy framework that Toronto's CRD waste system sits within, from federal to municipal. Throughout the project, visuals such as graphs, charts, infographics, maps, and diagrams are used to clearly communicate and quickly show complex concepts to bring an understanding of the system, problems, and solutions to a broader audience. This project emphasizes mapping and other visualization techniques to clearly identify, illuminate and explore existing barriers in the current system, possible future solutions, and identify leverage points for creating change and moving towards a circular economy for construction, renovation, and demolition waste in Toronto. Graphic analysis and information design curates and communicates a large body of research from across the world.

Hey@andHaley.com | HAnderson@Ryerson.ca | HumanCentredCities.com

CIRCULAR SOLUTIONS FOR
CONSTRUCTION, RENOVATION, AND DEMOLITION WASTE IN TORONTO

By

Haley Anderson

Bachelor of Design (Honours), York University, 2011

A Major Research Paper

presented to Ryerson University

In partial fulfillment of the requirements for the degree of

Master of Planning

in

Urban Development

Toronto, Ontario, Canada, 2021

AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A MRP

I hereby declare that I am the sole author of this MRP. This is a true copy of the MRP, including any required final revisions.

I authorize Ryerson University to lend this MRP to other institutions or individuals for the purpose of scholarly research.

I further authorize Ryerson University to reproduce this MRP by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my MRP may be made electronically available to the public.

CIRCULAR ECONOMY SOLUTIONS FOR
CONSTRUCTION, RENOVATION, AND DEMOLITION WASTE IN TORONTO

Master of Planning

in

Urban Development

Ryerson University

ABSTRACT

The city of Toronto is growing and changing rapidly, ever more now with the impacts of COVID-19 on the way people use and need space. With changing markets and needs, many opt to renovate or demolish and start new, all the while creating waste. This waste is often overlooked in conversations of green buildings and sustainable growth. This project uses systems mapping and visualization techniques to illuminate and explore existing barriers, possible solutions, and identify leverage points, in order to move towards a circular economy for construction, renovation, and demolition waste in Toronto. Visualizations illustrate the policy framework which influences Toronto's construction, renovation, and demolition waste (CRD) landscape, and explore strategy documents and processes produced by the City of Toronto. Inspiration for recommendations is drawn from policies, markets, and communities around the world.

Key words: circular economy, construction renovation and demolition waste, systems thinking, systems change, sustainable cities, sustainable, sharing economy, re-use remanufacturing and repurposing, waste management

ACKNOWLEDGEMENTS

Thank you to my supervisor Professor Nina-Marie Lister for the support, feedback, and motivation. Thank you to my second reader, Lisa King, Senior Planner with the Toronto City Planning Division for taking the time to share resources and feedback. Thank you to SURP alumi Nadia Dowhaniuk, Ross Edwards and Vickey Simovic for sharing ideas, conversations and research. Thank you to Emily Alfred at the Toronto Environmental Alliance for sharing so many great resources and ideas.

DEDICATION

To those who are working to make this world a better place for the future. This of course includes my brilliant classmates, friends and family. Thank you to Dave for motivating me and taking me for walks.

WHAT IS THIS PROJECT ABOUT?

The Project

- *Circular Solutions for CRD Waste in Toronto*
- *Limitations*
- *Contents*

Circular Solutions for CRD Waste in Toronto

The City of Toronto is constantly growing and evolving—an ongoing process that has significantly shifted due to the impacts of COVID-19, adjusting the ways that people are using urban space (Verma & Husain, n.d.). With changing markets and personal needs, many property owners are opting to renovate or demolish and build new homes, creating tonnes of waste that are largely unmonitored or measured. This type of housing waste and its negative environmental impacts are often overlooked or under-prioritized in favour of striving to reduce operational energy consumption and the specification of non-toxic materials in development policy and green building credits.

Although reducing operational energy needs, striving towards net-zero, designing healthier buildings, and ensuring toxic-free environments are certainly integral to this vision, the waste and emissions produced by construction, renovation, and demolition (CRD) of buildings also needs to be included in the conversation. In Canada, "CRD waste" is classified as non-hazardous waste; whereas "hazardous waste" is classified based on its flammability, toxicity, and corrosivity (Canada, n.d.-b, n.d.-a). Though CRD waste is not an imminently hazardous kind of waste, it can still contain dangerous chemicals that are harmful to humans and the environment if they are not managed properly (Canada, n.d.-b).

Often, the public discourse around carbon footprints and waste reduction focuses on consumer-level goods, including the fashion industry (Berg et al., n.d.), beauty products (Bailly, 2020), and food-related emissions and packaging (Marquis, 2021). To advance this discussion further, this project aims to leverage insights and techniques from these studies to shine a light on CRD waste: a less-publicized form produced by the construction, renovation, and demolition of residential homes in Toronto.

Planners work with a multitude of complex systems within cities. They strive to solve endless "wicked problems"—questioning not just the diverse elements that form urban systems, but also what these systems do, do not do, and could be doing to create significant change (Rittel & Webber, 1973). To establish the context of this particular wicked problem, the characteristics of Toronto's housing market are outlined and the current state of CRD waste in Canada is examined. In an effort to better understand the problem, this project investigates the current policy framework that Toronto's CRD waste system sits within—including federal, provincial, and municipal—to determine where missed opportunities and barriers exist within the housing sector.

This project emphasizes mapping and other visualization techniques to clearly identify, illuminate, and explore existing barriers in the current system and possible future solutions. It also identifies actionable items for creating change and moving towards a circular economy for CRD waste in Toronto. Exploring successes seen in other cities across the world at each stage of the building life-cycle will inform the discussion around potential circular solutions and tactics. Throughout, visuals such as graphs, charts, infographics, maps, and diagrams are used to communicate complex concepts—in an attempt to convey a clear understanding of the system, problems, and solutions to a broader audience. The focus on graphic analysis and information design has been key for collating a large body of research from across the world.

LIMITATIONS

Looking at the entire system of construction, demolition, and renovation of properties, there are countless places where environmental impacts can be reduced. Motivating industry stakeholders to adhere to sustainable extraction practices, reduce fuel consumption (e.g., by shrinking the distances that materials are transported), and develop more energy-efficient buildings all contribute to reducing the carbon emissions and waste associated with construction and urban development. This project specifically looks at understanding and curating solutions for the system in which waste is created by demolishing and renovating existing residential buildings in Toronto.

The choice to focus on residential renovation and demolition waste reduction is informed by research published by the Canadian Council of Minister of the Environment (CCME), which finds that CRD waste makes up the largest portion of building-related waste; even when compared to industry-scale building waste. As such, this project centres upon residential construction waste through a similar life-cycle mindset as an industry-wide perspective, aiming to create recommendations towards circularity that can also help reduce industrial waste. To define a specific problem for intervention, this project dives deeper into the key phases where CRD waste can be reduced before the building's end of life. This can be achieved by exploring policy levers that regulate the amount of allowable waste at the approvals phase, while also looking at alternative material and product choices in the design phase.

Contents

WHAT IS HAPPENING IN TORONTO?

The Context

- *People and Houses*
- *The Real-Estate Market*
- *Construction, Demolition, and Renovation*

People and Houses

Metropolitan areas like the Greater Toronto Area (GTA) are consistently growing year over year. This expansion does not need to be wasteful—research has consistently shown that concentrating growth in dense urban centres is much more sustainable when compared to sprawling suburban development (Blais, 2010). The Ontario Growth Plan—which will be explored in more depth later in this paper—designates where growth should be focused, based on strategies, targets, and objectives which are intended to "promote economic growth, increase housing supply, create jobs and build communities that make life easier, healthier and more affordable for people of all ages" (Ontario, n.d.).

> *"Toronto's population is expected to grow by 1.03 million people between 2016 and 2041."*
>
> *– Toronto Housing Market Analysis, City of Toronto, 2019*

The province of Ontario has identified four Toronto areas as "Growth Centres," with density targets to support this projected growth. The table below shows these targets, which all align with the municipal targets for four key areas: Downtown, North York Centre, Scarborough Centre, and Etobicoke Centre (Neptis, n.d.). These locations were selected due to their access to public transit and the policy goal of improving the commute for many residents, while spreading density throughout the city rather than just in the downtown core (Ontario, n.d.).

URBAN GROWTH CENTRE MINIMUM DENSITY TARGETS IN TORONTO

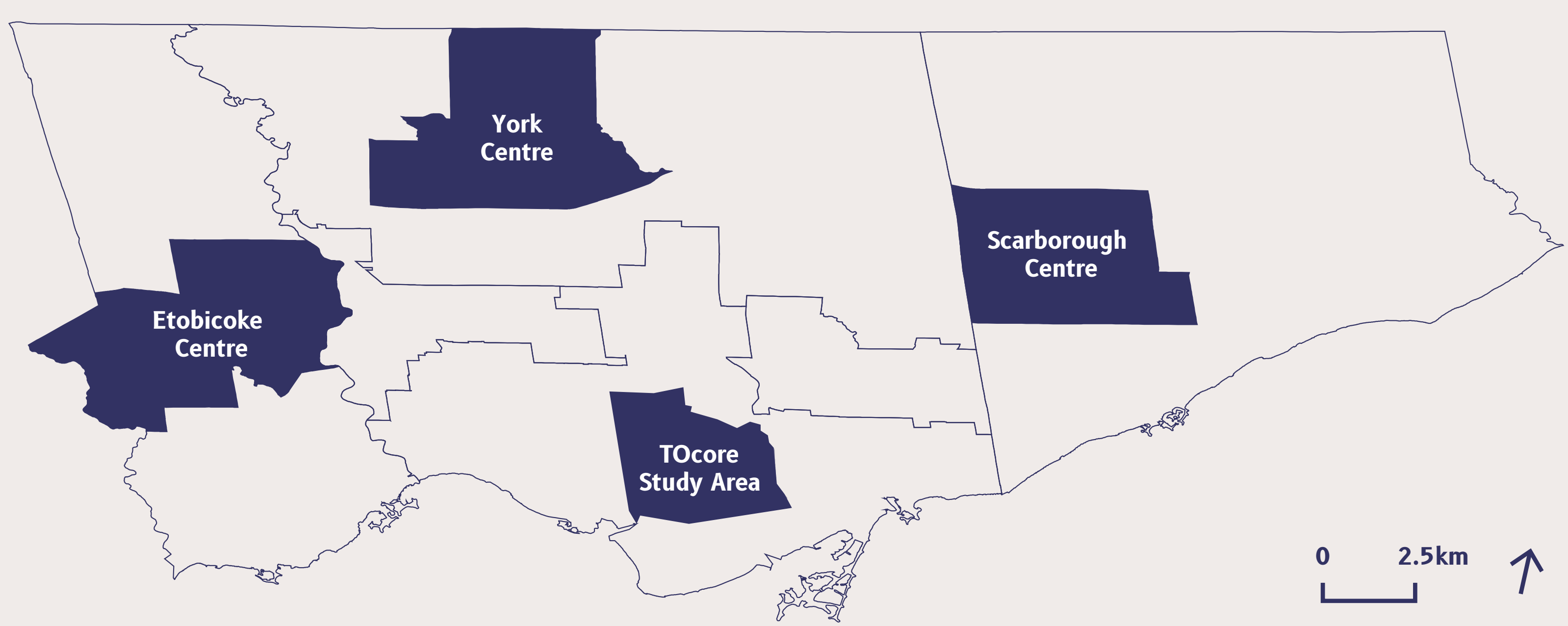
Urban Growth Centre Name	Area (ha)	2006 Density (people + jobs/ha)	2031 Growth Plan Density Target and Municipal Density Target (p+j/ha)	Increase in Population and Jobs (2006-2031) Required to Meet the Minimum Density Target (%)[1]
Downtown	2,120	280	400	43%
North York Centre	191	391	400	2%
Scarborough Centre	174	143	400	180%
Etobicoke Centre	165	131	400	205%

Source: (Neptis, 2019)

It is expected that Toronto's population will grow by 1.03 million residents between 2016 and 2041, and—according to the 2016 Census—there are 1,112,930 households in the city (City of Toronto, 2019). Comparing these two statistics, it is clear that there must be considerably more housing development to accommodate the impending influx of people to Toronto. As demand for housing increases due to population growth, the market is becoming more and more expensive, and people are being priced out of the downtown core and drawn to suburbs such as Etobicoke and Scarborough (Simonpillai, 2021).

According to the 2016 Census, Scarborough Centre and Etobicoke Centre's housing stock is comprised of 34% and 48% single-detached housing, respectively (Etobicoke Centre: City of Toronto Ward Profiles, 2018; Scarborough Centre: City of Toronto Ward Profiles, 2018). According to their census profiles, these two wards had a combined 85,335 households, with most of the ground-related dwellings (including single-detached and semi-detached homes) being constructed before the 1960s. This not only means that the existing housing stock is not sufficient to serve the future populations, but also that the infrastructure is aging and will need repair or replacement. These houses were designed to suit residents with much different lifestyles as compared to the needs of current and future populations.

WHERE GROWTH IS DESIGNATED IN TORONTO



Map by the author, data sources:
City of Toronto. [2018]. Wards [Data file]. Retrieved from https://open.toronto.ca/dataset/city-wards/; City of Toronto. [n.d.]. Regional Municipal Boundary [Data file]. Retrieved from https://open.toronto.ca/dataset/regional-municipal-boundary/

THE CONTEXT

The Real Estate Market

The COVID-19 pandemic has magnified the importance of how people use their space at home. With much of the workforce in Toronto now working from home—spending nearly all of their personal and professional time in the same building—people have had to find creative ways to adapt to their needs by adding home offices and shifting their possessions around their spaces. Many families are also turning their homes into classrooms, through homeschooling or virtual school. As such, people are increasingly looking for more flexibility in, and different uses from, their homes.

At the same time, as people spent additional time at home with less ability to engage in external activities, many have found the time to renovate and finally tackle domestic construction projects. Building supply stores have remained open for curbside pick-up and in-store shopping throughout most of the pandemic, yet contractors and homeowners have had to spend an increasing amount of time searching for lumber supply (Armstrong, 2021).

This is in part due to international borders being closed, which slowed down the delivery of supplies considerably (Armstrong, 2021). The overall lumber supply has also been significantly reduced, due to closed lumber mills in British Columbia due to fires and pine beetle infestation, as well as temporary interruptions to production due to the COVID-19 pandemic and lockdowns (Healing, 2020). The increased demand and lack of supply this year has resulted in record high prices of lumber, adding between $5000-$30,000 to the price of building a new single-family home (Armstrong, 2021; Healing, 2020).

A survey published by RE/MAX in September 2020 found that:

> *“44% of Canadians would like a home with more space for personal amenities”.*
>
> *–Verma & Husain, n.d.*

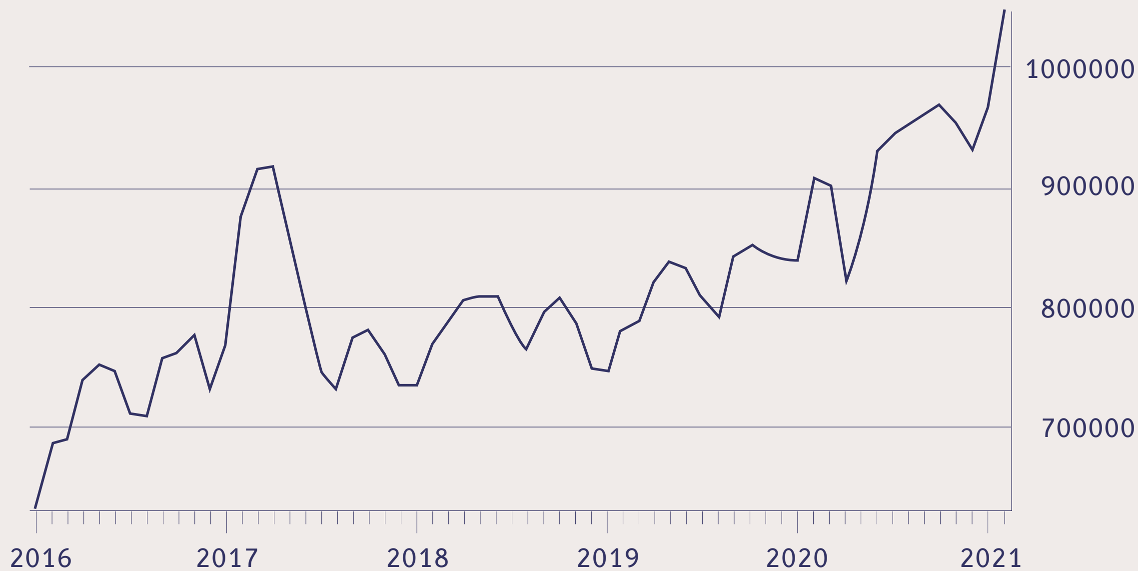
The combination of these housing sector factors—i.e., a lack of supply and an increased demand for housing due to long-term population increases, as well as the very present desire for more space at home—has created a seller’s market (Ireland, 2021). According to the Toronto Regional Real Estate Board (TRREB), in just the last two weeks of March 2021, 9,148 homes were sold in the GTA. This demand has caused prices to skyrocket: the average price for a Toronto property has now reached $1,000,000 CDN for the first time (Hall, 2021).

Motivated by money, homeowners have been inspired to quickly renovate and sell their property for a much larger profit than previously imagined—commonly known as “flipping” (Urbaneer, 2019). Real-estate agencies like Royal Lepage have published lists of home renovation ideas and tips that ensure sellers will maximize profits. For instance, homeowners can most efficiently increase their profits by renovating or remodelling their kitchens, which can potentially increase the selling price by up to 12.5% per room (Armani, 2020).

With such a competitive market, buyers are not guaranteed to find a property that suits their individual specific needs. Many buyers and house-flippers are thus turning to a newer trend, known as the "teardown," to achieve more space in their houses (Rawcliffe, 2008). Buyers are often purchasing cheaper properties for the land, knocking down the existing house to rebuild a new, bigger, or more luxury home for themselves, or to sell at an up-market rate (Walden, n.d.).

This section demonstrates how there are many constantly changing factors that increase CRD waste across the GTA: housing demands are changing rapidly, scarce resources and building materials are being bought up, and waste is being generated at never-before-seen levels—and will continue to be generated at higher rates, as these CRD trends show no signs of slowing.

TORONTO'S AVERAGE PROPERTY PRICE EXCEEDS C$1M



Toronto's Average property price tops C$1m for the first time. [Average selling price C$]

Data source: [Hall, 2021]

Construction, Renovation, and Demolition

RESIDENTIAL CONSTRUCTION SPENDING IN ONTARIO

($ Billions annually in 2019)

RENOVATION SPENDING

Considering the high rates of return on investment, it is no surprise that Ontarians spent $34.2 billion, or 61% of housing spending, on renovations in 2020 (Altus Group, 2020). Of that 61%, $26.8 billion was spent on alterations, improvements, and conversions, with the remaining being spent on repairs (ibid.).

Graphic adapted from: [Housing Report: COVID-19 to Dent Renovation Spending, a Vital Driver of Canadian Economic Activity, 2020].

TYPES OF WASTE GENERATED FROM CRD

Building Stage	Residential	Non-residential	Total CRD waste
Construction	15%	5%	444,700 tonnes [11%]
Renovation	57%	32%	1,873,200 tonnes [47%]
Demolition	28%	63%	1,668,900 [42%]
Total amount of CRD waste	2,443,900 tonnes [61%]	1,562,800 tonnes [39%]	~4 million tonnes [100%]

Data from: [CMME, 2016].

RENOVATION WASTE

In Canada, the main source of CRD waste is residential renovations at 61%, with the remainder being attributed to non-residential buildings (i.e., offices and industrial structures) (Canadian Council of Ministers, 2019). Of the residential CRD waste generated, 57% of that waste is from renovations (ibid.).

From Materials to Landfill

CRD waste is often consolidated, or all thrown into one big bin, which is then picked up by private waste management firms like Waste Management (WM) or "Rid of It – Junk Removal." Without separating and sorting the contents at the work site, these it is difficult to retrieve salvageable materials from these bins without appropriate services at the Materials Recovery Facility (MRF) (Green Blue, n.d.). Without the participation of the waste generator or demolition crew, recycling and reuse of CRD materials does not typically happen in practice (Green Blue, n.d.).

Based on a study of CRD waste in Canada, the waste generated from CRD is made up of, by weight, the materials identified on this page. In many cases, although there are markets for salvageable materials, there is a lack of education and awareness of how to deconstruct buildings, dispose of waste, and make connections to markets for CRD waste (Green Blue, n.d.). Outside of studies like this, facilities are not mandated to publish their diversion rates—and thus, CRD waste goes largely unmonitored.

KEY CRD WASTE MATERIALS

40%
WOOD

- 49% – Clean wood
- 23% – Engineered Wood
- 20% – Painted wood
- 8% – Treated wood

9%
DRYWALL

4%
CONCRETE

4%
PLASTICS

- Rigid insulation
- Carpet
- Other plastics

3%
METALS

10%
ASPHALT ROOFING

1%
CARDBOARD

29%
ARCHITECTURAL SALVAGE

Including High Value Items:

- Steel and wood beams
- Plumbing fixtures etc.

29%
OTHER MATERIALS

- Aggregates
- Asphalt paving
- Bricks
- Ceiling tiles
- Equipment
- Fibreglass
- Paint
- Mixed glass (Windows, Mirrors etc.)

Graphic created by the author. Data from: [CCME, 2019]

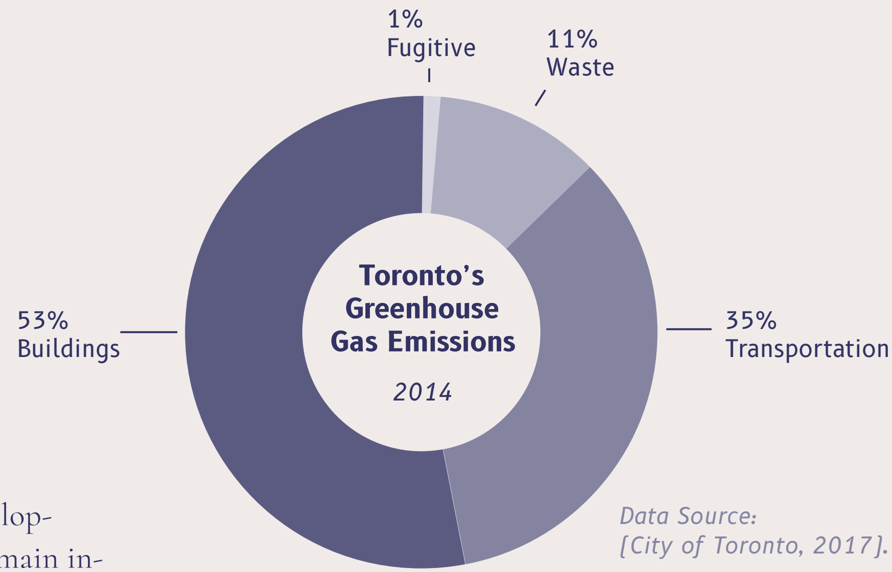
WHAT IS THE IMPACT OF ALL OF THIS?

The Problem

- *The Climate Crisis*
- *Embodied Carbon*

THE PROBLEM

The Climate Crisis



GREENHOUSE GASES

In Canada and countries around the world, societies are extracting, transporting, and disposing of valuable resources at an unsustainable rate (IPCC, 2018). It has been known for decades that physical growth and dependence on non-renewable resources cannot be exponential (Meadows, 1972). This continued practice contributes to the release of dangerous greenhouse gas (GHG) emissions, which result in climate change and the many deadly impacts that come along with it (IPCC, 2018). The International Panel on Climate Change (IPCC)—the United Nations' science body that assesses climate change—stated that global emissions must fall by 45% from the 2010 measurements by the year 2030, in order to prevent global temperature increases which are detrimental to human and other life (Hunziker, 2021; (IPCC, 2018).

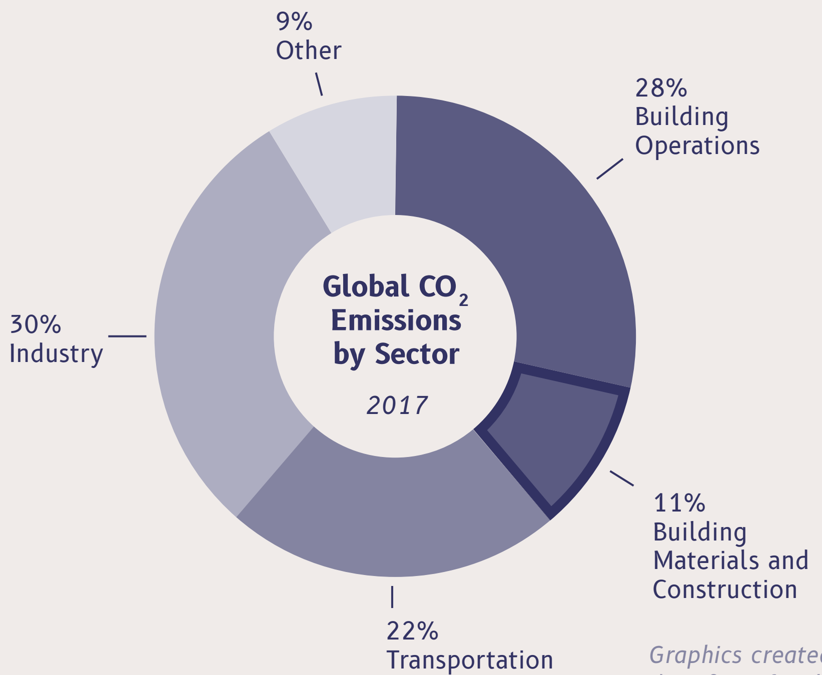
We are not on track to meet emissions targets set by the IPCC. Human activity and development in urban centres remain incredibly wasteful and dependent on non-renewable resources, despite efforts to become more energy efficient through increased awareness and new adaptations, such as: passive house design for reduced energy consumption and "smart grid" technology to improve energy delivery (Simovic, 2019). The most recent version of Toronto's Green Building Standards (Version 3) is largely focused on measuring and reducing GHG emissions caused by buildings—which amount to 53% of Toronto's total GHG (City of Toronto, 2017). This measurement, however, only accounts for the energy consumption performance that is required to operate these buildings; notably, it does not include the GHG or carbon emissions from the building materials themselves.

EMBODIED CARBON

To understand the entire picture of CRD waste, it is important to measure embodied carbon. This involves a scientific approach which factors in the life cycle of GHGs that a material or process generates from a holistic view.

The measurement of embodied carbon includes the amount of GHGs, including Co2, released during the whole life cycle of a material, from extraction to manufacturing (Peck, n.d.). For example, a common building material such as steel begins its life at extraction.

The various elements that make up steel—like carbon and manganese—must be mined, refined, and combined. As such, an embodied carbon measurement takes a "complete life cycle view" of what it takes to bring buildings into existence, as compared to an "operational view" of emissions released as buildings are being used (i.e., during heating, cooling, and other energy consumption-based activities). This life cycle type of measurement thus widens the timeframe in which emissions are measured and examined and includes emissions created by extraction, manufacturing, processing, transportation, and assembly of every part of a building before it existed (BuildingEnergy Boston, 2019).



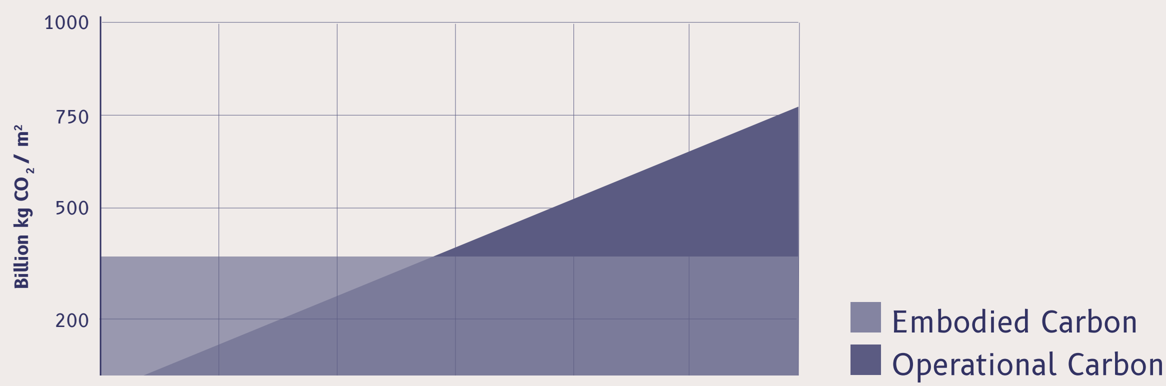
Graphics created by the author, based on data from [Architecture 2030, n.d.].

LIFE CYCLE ASSESSMENT

A life cycle assessment (LCA) is a process, framed by ISO standards, used to assess the environmental impact of a product or an entire building (Peck, n.d.). It examines each stage at which resources are consumed, as well as when emissions or substances are released, beginning with natural resource extraction through to the end of a product's life (Peck, n.d.). Though LCA's are not the only method for measuring the entire embodied carbon and environmental impacts of a product from start to finish, it is among the most commonly used by researchers and industry (Peck, n.d.).

TOTAL CARBON EMISSION OF GLOBAL NEW CONSTRUCTION FROM 2020-2050

BUSINESS AS USUAL PROJECTION



Graphic created by author based on data from [Architecture 2030, n.d.].

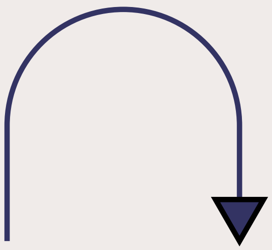
HOW CAN THE CIRCULAR ECONOMY HELP?

The Solution

- *What the Circular Economy Is Not*
- *What the Circular Economy Is*
- *The Ellen MacArthur Foundation*
- *Sustainable Materials Management, Lund University*

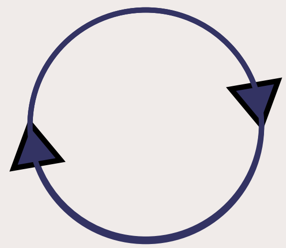
THE SOLUTION

The Circular Economy



WHAT IT IS NOT

The current economic model supports a linear "take-make-waste" structure (Ellen MacArthur Foundation, n.d. a). Yet exponential consumption cannot continue within the bounds of restricted global resource availability, and there are very real natural limits that are being ignored (Meadows et al., 1972; Rockström et al., 2009; Steffen et al., 2015). If we continue in the same linear way, we will experience several unfortunate consequences: running out of safe, useable resources; soaring carbon emissions; and overflowing landfills, which will force us to dispose of materials closer and closer to human settlements, to our detriment (Bocken et al., 2016).



WHAT IT IS

The origin of the concept of the Circular Economy (CE) cannot be attributed to one person or event. Although it began to surface and gain traction in the late 1970s (Schools of Thought, n.d.), CE is also a modern and emerging concept seen as an alternative to the current linear economy (Cavaleiro de Ferreira & Fuso-Nerini, 2019). In the CE model, waste and emissions are designed out of the system by "slowing, closing, and narrowing material and energy loops through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Florez Ayala & Alberton, 2020; Canadian Council of Ministers of the Environment, 2019).

There are many schools of thought that fall under the umbrella of CE, including the cradle to cradle (C2C) concept. C2C is a design philosophy which adopts a biomimicry-like approach by positioning resources as nutrients which feed into the broader "food chain" or "ecosystem" of living matter within global systems (Benyus, 2008; Florez Ayala & Alberton, 2020; CCME, 2019; McDonough et al., 2008). C2C aims to eliminate the concept of waste by re-designing the role of materials to decompose or be deconstructed into their elements—absorbed back into a cycle where they will "feed" the system, to be used again to create new things.

Discussion around CE and its benefits has not fully saturated the North American market. Thought leadership and adoption on a systemic scale is more prominent in the UK and Europe; most notably in the Netherlands, Scandinavia, and Belgium (Alnajem et al., 2021; Korhonen et al., 2018). However, Canada is beginning to explore circularity at all levels of government as outlined in the 'Policy Framework' section of this paper. This movement comes at a time when the concept of "Zero Waste"—another school of thought

[Graphics based on: 'Circular Economy framework' Nancy M. P. Bocken, Ingrid de Pauw, Conny Bakker & Bram van der Grinten [2016]

that has ties to CE—has gained traction in many communities, thanks to the work of activist and environmental circles who have been actively requesting that governments across Canada ban single-use plastics (Environment and Climate Change Canada, 2020). Due to these combined efforts, the Canadian government has now issued a ban of harmful single-use plastics, with a goal of zero plastic waste by 2030 (Environment and Climate Change Canada, 2020). A proposed order will be published to add "plastic manufactured items" to the Canadian Environmental Protection Act, 1999 (CEPA, 1999). CEPA is one of Canada's key laws for protecting the environment and preventing pollution, and now includes tools for addressing plastic pollution throughout different life cycle stages of plastic items. Additionally, CEPA will soon be updated to state that all Canadians have the right to safe and healthy environments (Taylor, 2021; The Canadian Environmental Protection Act, 1999 (CEPA 1999), 2017).

For significant economic transformation, a circular transition is required—away from the prevalent "linear economy" to a closed-loop model where a product is sold, consumed, collected and then reused, remade into a new product, returned as a nutrient to the environment, or incorporated into global energy flows (Giroux Environmental Consulting 2014; CCME, 2019). CE is rooted in taking a holistic view of a system, and this kind of transformation relies on making connections, collaboration, and communication to solve such a wicked problem. In other words, the active development of a complex social, organizational, and political system that needs multidimensional approaches and relationships to unravel (Ritchey, 2011).

Communication and dissemination of CE can most often be traced to the Ellen MacArthur Foundation (EMF). Their work covers several industries and issues including food, plastic, and buildings; often partnering with large multinational corporations like Unilever, H&M, IDEO, and IKEA. The open-source publications that the foundation produces provide deep insights through case studies, resources for learning circular basics, application toolkits, videos in conversation with international subject-matter experts, and much more (The Ellen MacArthur Foundation, n.d.).

SUSTAINABLE MATERIALS MANAGEMENT, LUND UNIVERSITY

In an effort to share the knowledge and successes gained through implementing circularity, the University of Lund in Sweden—in partnership with other institutions and research agencies—created a massive open online course (MOOC) called Circular Economy - Sustainable Materials Management (Dalhammar et al., 2019; Peck, n.d.). This course covers topics such as critical materials and extraction, circular business models, circular design and innovation, life cycle assessment, circular policies, and community engagement (Peck, n.d.). Video lectures and case studies, curated literature, and skill-building tools and activities for applying circular thinking are all delivered by expert researchers and practitioners from across Europe (Peck, n.d.). Much of the foundational information and many research leads for my work began with course material and lessons from this course.

WHAT IS IT LIKE NOW?

The System

- *Mapping and Visualization*
- *From Resources to Buildings*
- *Waste Hierarchy*
- *Stakeholder Mapping*
- *Policy Framework*

Mapping and Visualization

Systems thinking principles are rooted in challenging the underlying structure of a system by asking why a system exists the way it does—instead of just analyzing what the system does (Meadows & Wright, 2008). During her illustrious career, Donnella Meadows was among the preeminent thought leaders in the study of systems. She was also an environmentalist—founding the Sustainability Institute (now called Academy for Systems Change) in the mid 1990s (DonellaMeadows.org, n.d.)—and emphasized that systems change must begin with a vision for a sustainable future (Meadows, 1994). With this vision and an understanding of how a system works, by mapping the structure and behaviour of it, we can then begin the challenging work of shifting the system (Meadows & Wright, 2008).

Seeing a whole system requires an understanding of its relationships and flows, recognizing that the system is more than the sum of its parts (Meadows & Wright, 2008). Leverage points (i.e., opportunities to create change and shifts) can then become clear (Meadows, 1999). For instance, when a building permit is required, the information provided to the applicant should include waste reduction resources to advance sustainable practices from the outset. This example demonstrates the importance of locating responsibility within the systems, and identifying the impact of high-level decision-making (Meadows & Wright, 2008). One practical application of this research is Peter Checkland's work in systems thinking—known as "soft systems methodology"—with its emphasis on using visualizations to improve decision-making in real-life problematic situations (Checkland & Poulter, 2010). Visualizations of thinking, systems, data, and concepts help to communicate complexity and bring understanding and common ground amongst diverse disciplines; with vast potential to make information more accessible to diverse audiences (Bamforth, 2011; Checkland & Poulter, 2010). For these reasons, this project has incorporated and adapted many existing visualizations of information as well as creating several new visual maps of systems and diagrams.

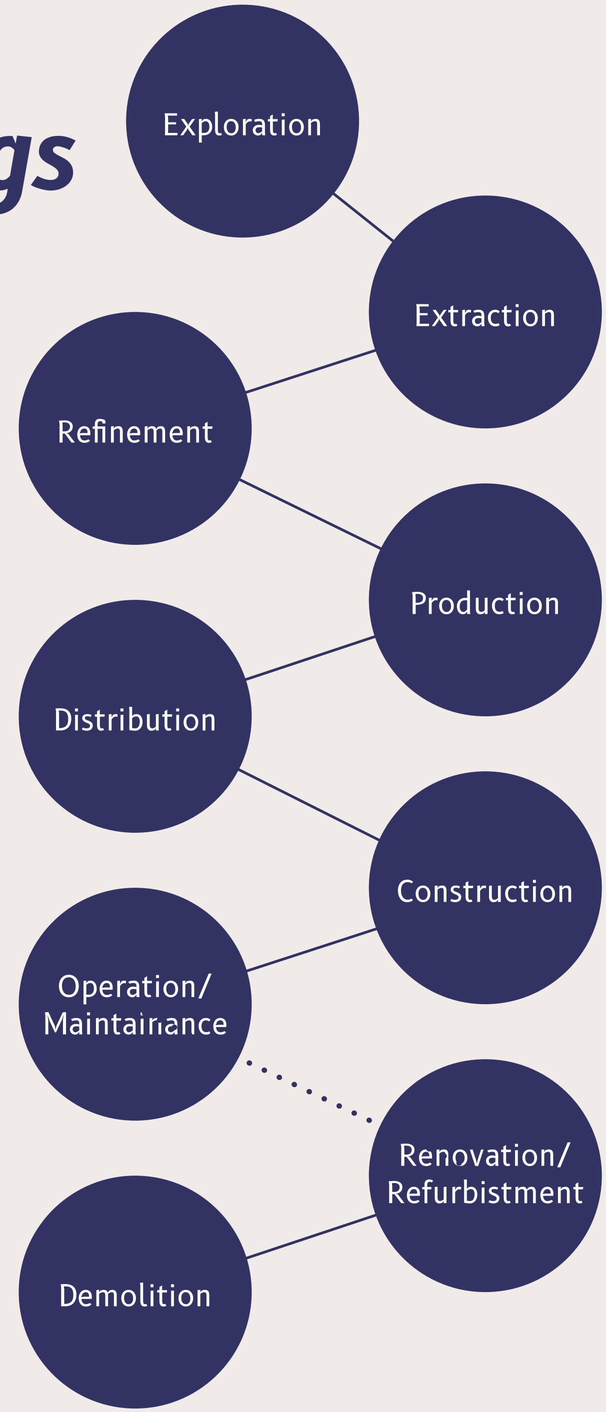
MAP THE SYSTEM

Map the System (MTS) is an international competition initiated by Oxford University in the UK, which challenges students globally to think about social and environmental issues in a visual and systemic way (Map the System, 2020; Map the System, n.d. b). As part of this challenge, Ryerson University's School of Social Innovation hosts a series of collaborative skill-building workshops and shares many resources developed internally—specifically to support students in creating a submission to MTS. Many of the tools and resources provided by this supportive community have been used as a starting point for developing the visualizations in this document (Map the System, 2021).

SEVEN GENERATIONS

Through the School of Social Innovations MTS workshops, the tie to "seven generations thinking" was made (Map the System, 2021). System mapping cannot be discussed without acknowledging its ties to the seven generations model. This worldview places each of us in the middle of seven generations of existence, passed on from elders to be handed off to our children in order to build continuous community knowledge. "Sharing information and building collaborative ways of engagement are central to a seven generations model" (Jojola, 2013).

From Resources to Buildings



RESOURCES TO PRODUCTS

Before a building exists, its materials must find their way to the building site. The phases visualized above trace the common, high-level journey of how resources become brand new materials (Dalhammar et al., 2019; Peck, n.d.). Importantly and unfortunately, GHG are emitted at each stage.

First, a particular resource must be discovered or located through "exploration" and then "extracted" from the ground through mining processes. Next, "refinement" occurs, which typically refers to the process applied to mixed resources. Often, when elements are brought out from the earth, they are bound to many other materials—and must be refined to produce more pure materials like copper, as well as alloys like steel (Peck, n.d.). "Production" then takes these raw materials and turns them into building materials like steel beams, wires, nails, and different types and sizes of lumber. Finally, to get these products to building sites, they must be "distributed" through shipping, and then stored and sold through distributors.

PRODUCTS TO BUILDINGS

The typical linear building life-cycle can be distilled into these four basic phases. Note that many other activities occur before construction, including planning and design, which dictate the kind of building that is allowed on a site and the materials that will be used to construct it—but these considerations are outside the scope of this paper.

For the purposes of this visualization, the stages shown follow the flow of the newly produced materials, which makes "construction" the next logical step after material distribution. The materials are then transformed into a livable building, requiring services like water and energy (and occasionally additional materials) to maintain and repair the building throughout "operation." Some companies and owners may also opt to "renovate" and change the building with additions or remodelled rooms, consuming even more materials. At the end of the life-cycle, a building that is no longer livable or desirable is typically "demolished," in whole or in part (Foster, 2020).

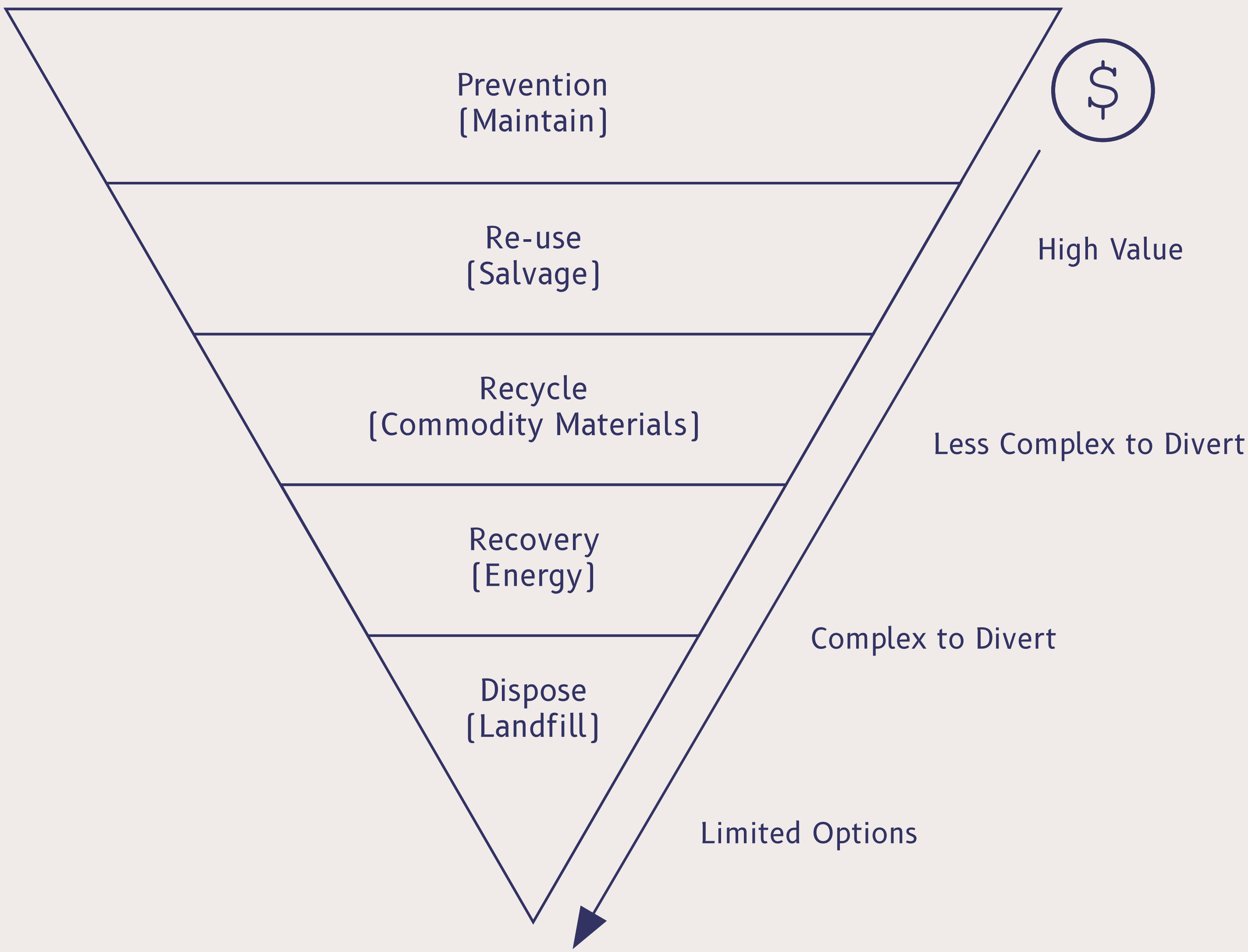
Waste Hierarchy

A hierarchy of ways to handle waste helps to bring an understanding of waste management beyond the "3 R's" (reduce, reuse, and recycle). Many waste-producing industries, such as the food industry, have their own waste hierarchy or framework (Papargyropoulou et al., 2014). This inverted pyramid graphic ranks "Prevention" above all else and "Disposal" as the last resort—ranking the waste handling strategies from the least-negative environmental impact at the top to the most-negative impact at the bottom.

Unfortunately, environmental impact is not the only influence in how industry prioritizes waste management. The market value of waste materials—both in their ease of reuse and end-user market demand—factor in greatly, meaning that reuse and recycling are only possible when value is attached to the material (CCME, 2019).

Prevention of waste entirely is clearly the best option for future sustainability. One form of prevention is "adaptive reuse," which keeps existing structures and materials on site and incorporates them into the new build. The salvaging of materials can create new local industry and markets for building materials like beams and bricks that are transported, stored, and used at other building sites. For instance, recycling building materials like copper is a long-standing industry practice, due to its high market value as a raw material.

Overall, the inverted pyramid shows the efficacy of different industry initiatives. Ideas such as recovering energy by using wood as fuel is better than disposing of it in a landfill; however, any of the above options rank higher in terms of reducing environmental impacts.



Graphic created by author with inspiration from [CCME, 2019; Papargyropoulou et al., 2014].

THE SYSTEM

Stakeholder Mapping

Stakeholder mapping is a people-centred approach within the system mapping and service design toolkit—designed to represent and communicate complex relationships within systems. Stakeholder maps are used as tools to facilitate conversations that help decision-makers understand, analyze, imagine, and design new solutions. Creating a stakeholder map serves as an illustration of the present waste generation processes, stakeholder relationships, and the current exchanges of value within the system. It helps to clarify the roles of actors by spatially and visually organizing their relationships and power dynamics. Illuminating these roles can shine a light on equity challenges, as well as highlighting barriers or missing connections between actors in a system. For the purposes of this project, this stakeholder map has been created using high-level stakeholder groups (i.e., “actors”) as the entry point to a complex system, which also involves many “sub-actors” who play similar roles.

THE BUILDING BLOCKS OF A STAKEHOLDER MAP ARE:

POWER

A base-map which represents how integral a stakeholder is, or how much power a stakeholder has, based on their placement in proximity to the center of the map.

STAKEHOLDERS

END USERS AND MARKETS

A symbolic or text-based representation of either the high-level actors in the system, or an in-depth mapping of all stakeholders who influence, participate in, and uphold the system.

RELATIONSHIPS

An arrow or connecting line between stakeholders to represent their relationship in the system.

EXCHANGES

i

Usually a text-based representation of the contribution or value transfer from one stakeholder to another.

Actors Involved in the Production and Management of CRD waste*

CRD WASTE GENERATORS

Entities that generate waste and have a role in reducing volumes created.

- Homeowners
- Designers (architects, engineers etc.)
- Building owners and develtopers
- Builders (contractors, trades)
- Demolition contractors, salvagers

REGULATORS

Governments, agencies and standards organizzations responsible for controlling CRD waste management.

- Federal, provincial and municipal governments
- Standards organizations

TRANSPORTERS

Companies that move waste from the point of generations to the facilities and end users.

- Hauling companies

FACILITIES

Companies and agencies responsible for receiving, sorting and processing CRD waste.

- CRD waste processors, also known as material recovery facilities (MRF's)
- Transfer stations
- Waste/material haulers and equipment renters
- Landfill operators

END USERS AND MARKETS

Organizations involved in the sale and reuse of CRD materials

- Public procurement agencies
- Product manufacturers and suppliers
- Wholesalers, retailers (with or without deconstruction or installation services)
- Materials exchanges

OTHER STAKEHOLDERS

Organization with interests in CRD waste management.

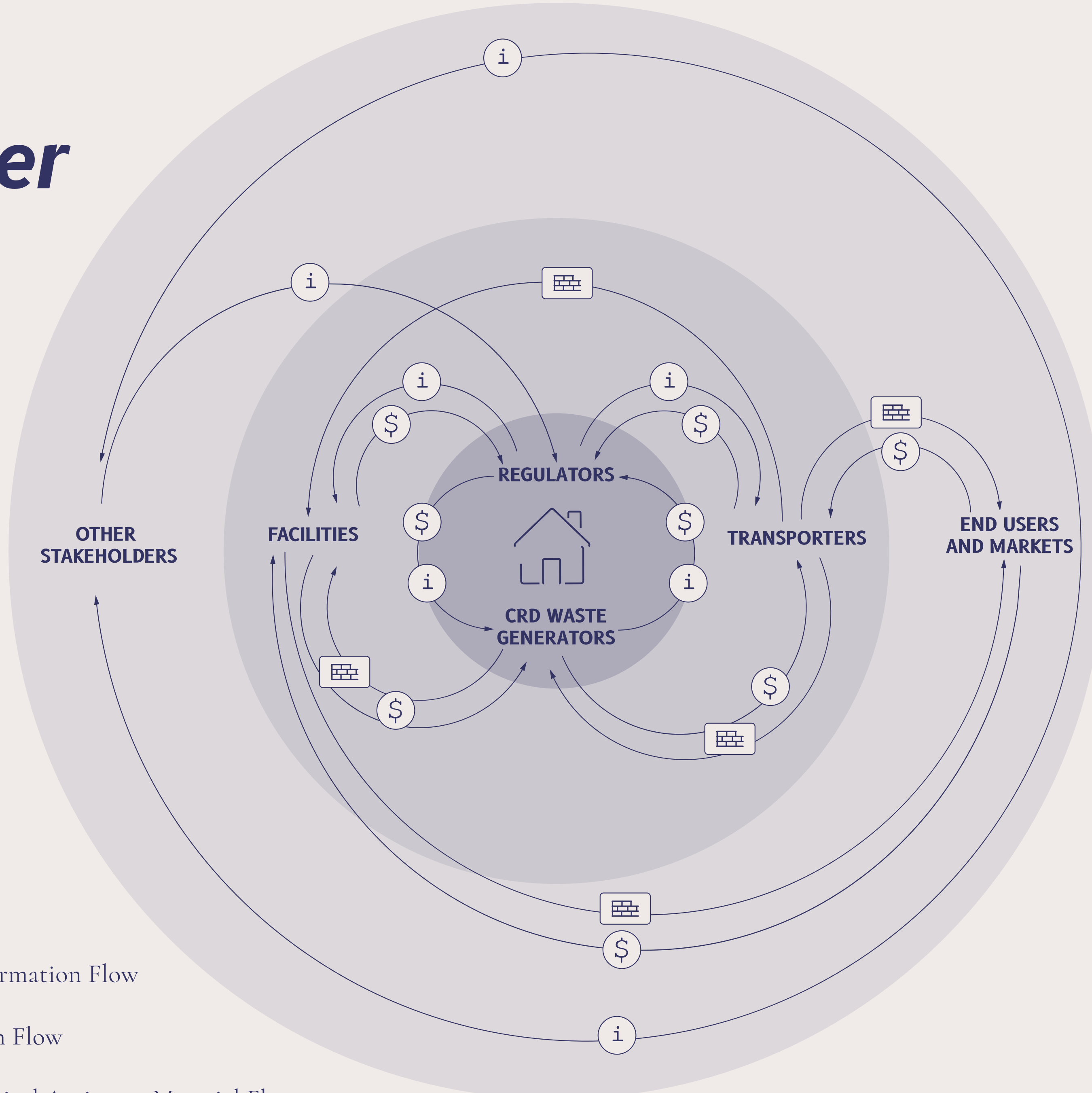
- Industry associations and councils (e.g., trade associations and procduct councils)
- producer responsibility organizations (PROs)
- NGOs
- R&D centres

This table was visually translated from the information provided in the [CCME, 2019].

THE SYSTEM

Stakeholder Map

This stakeholder map takes the high-level actors listed on the previous page and maps them based on their hierarchy of power and ability to impact the system or generate waste—with those who hold the most power in the centre. A layer of interrelated arrows shows the relationships between each actor as well as what is exchanged in the relationship, denoting the flow of information, money, and materials.



CRD WASTE STAKEHOLDER RELATIONSHIPS, VALUE EXCHANGES, AND IMPACT

High Impact
Medium Impact
Low Impact

i Information Flow
$ Cash Flow
Physical Action or Material Flow

Graphic Created by Author. Information analyzed from [CCME, 2019; Rau et al., 2020].

Stakeholder Relationships

REGULATORS + GENERATORS/ TRANSPORTERS/ FACILITIES

Regulators uphold policy which informs generators, transporters, and facilities on how to handle waste. Regulators may provide incentives for meeting waste-reduction targets set by policy. Mandatory regulations must be complied with; otherwise the generators, transporters, and facilities are subject to paying fees for non-compliance.

GENERATORS AND TRANSPORTERS

Waste generators work with transporters and exchange money to remove unwanted waste materials.

GENERATORS AND FACILITIES

Some generators may not hire a transportation or hauling company, instead working directly with a waste facility to receive, store, and sort materials. Depending on the type of materials and their current market value, payment for receiving materials may go to the generator, or the generator may have to pay a fee to dispose of waste materials.

TRANSPORTERS AND FACILITIES

The relationship between transporters and facilities is similar to generators—the main difference being the added step of professional transportation services on behalf of the generator.

FACILITIES/ TRANSPORTERS AND END USERS AND MARKETS

End-users and markets can work with facilities and transporters to source materials that have market value.

OTHER STAKEHOLDERS AND REGULATORS

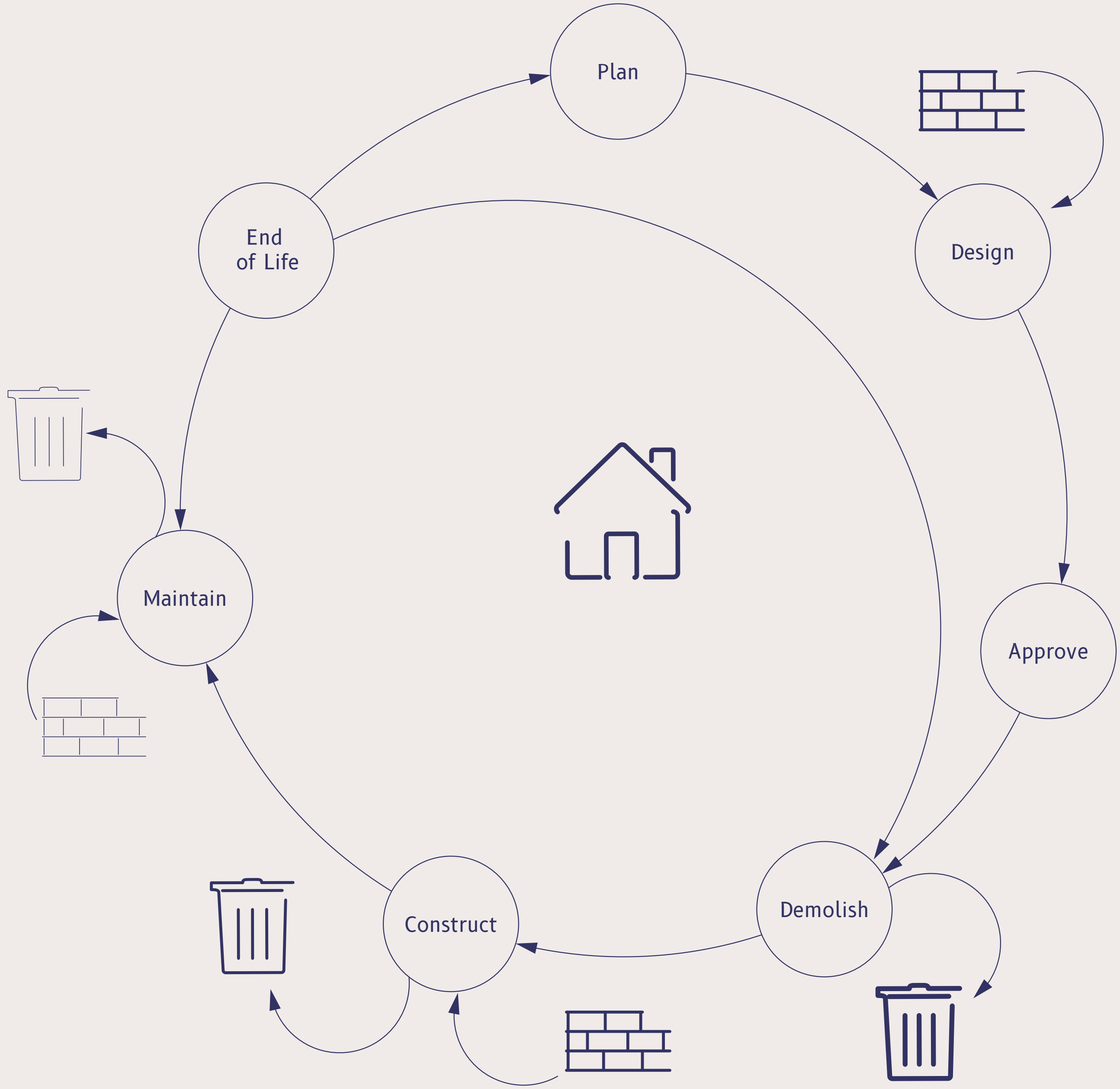
Organizations just outside of the system include those that produce research on waste and materials. This information is often provided directly to regulators, who may then make policy decisions based on the information provided. Advocacy groups and special interest groups often create campaigns and communicate broadly about waste and material-related information, or interact directly with council members, to influence decisions.

THE SYSTEM

High-Level Process Flow Map

MATERIALS IN, WASTE OUT

A process flow map is a helpful visualization tool which shows the high-level sequence of events. Seeing when and where phases connect with one another helps to emphasize the fact that each phase is interrelated and builds on the last—whether the stakeholders involved are intentionally working together or against one another. At every step in the life cycle of a building, decisions are made to bring new materials in, or push waste out, from the building site. In this process flow map, "materials in" is symbolized by a brick icon and 'waste out' is symbolized by a trash can. The most typical process that the building industry follows currently is composed of these seven phases.

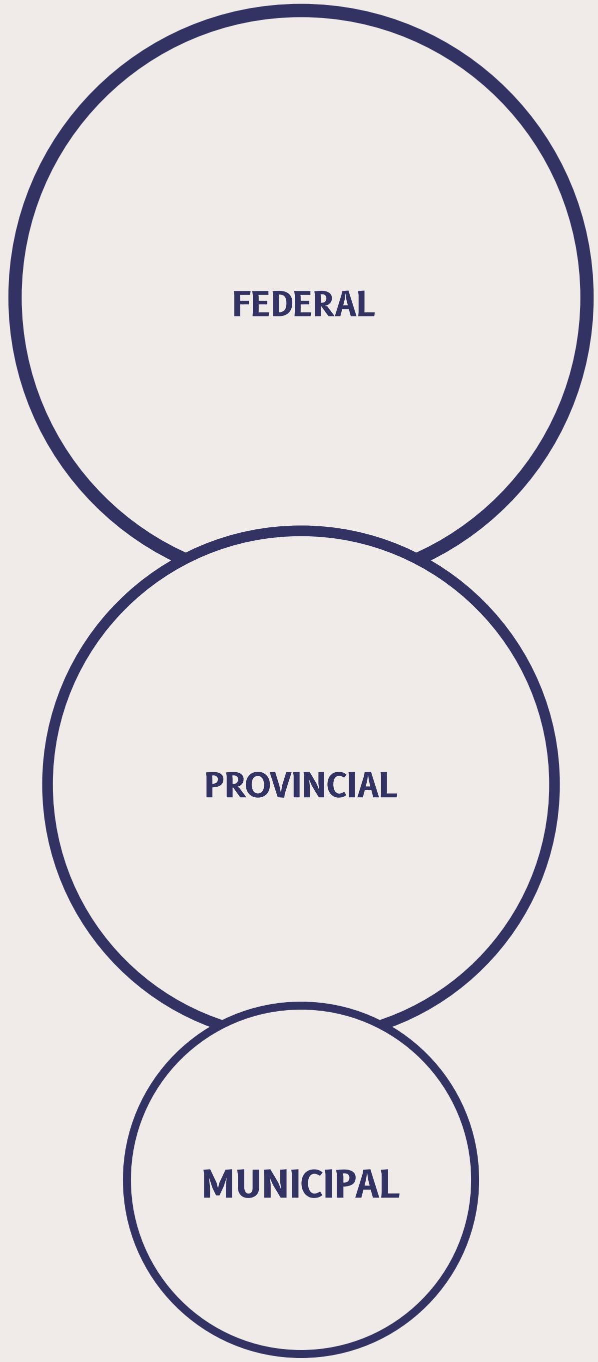


Graphic developed by author with inspiration from [Ali Akhtar, Ajit K. Sarmah, 2018, Foster 2019]

Policy Framework

Within this section, policy relating to CRD waste regulation and monitoring is examined at various levels of government administration, from federal to municipal. Canada's approach to Municipal Solid Waste (MSW) is decentralized, which means that responsibility is spread across different levels of government based on several characteristics, such as waste type or location (United Nations, 2019). MSW in Canada includes waste produced by residences, institutions, business activities, and construction and demolition waste (ibid). The Government of Canada provides broad guidance, support, tools, and funding to other levels of government to encourage sustainable MSW practices (Canada, n.d.-a, n.d.-b). The federal government does not otherwise get involved in waste-related issues, unless their lands or resources are impacted; or, in some instances, if the issues involve toxic substances or GHG. At the next level of government, the Provinces are responsible for regulation and policy frameworks that inform waste management operations like approvals, licensing, and monitoring for their municipalities. Collection, diversion, and disposal of MSW is the responsibility of the municipality (Canada, n.d.-a, n.d.-b).

The policy framework which influences Toronto's construction, renovation, and demolition waste landscape is explored through a review of laws, policies, strategy documents, and processes produced by the Federal Government of Canada, the Province of Ontario, and the City of Toronto. Inspiration for new policy recommendations and change is drawn from policies, markets, and communities around the world.



The Federal Goverment

Collaborating with the provinces, territories, municipalities, and indigenous partners, the federal government co-develops and implements standards for waste-related matters that are of common concern (Canada, n.d.). As stated early in this project, CRD waste is classified in Canada as non-hazardous waste (Canada, n.d.-b, n.d.-b). Federally, the prevention of hazardous waste and pollution is of primary concern over any non-hazardous waste management, including CRD waste (Canada, n.d.-b). Guiding this approach to Canadian waste and the environment are many laws, strategies, and handbooks.

FEDERAL SUSTAINABLE DEVELOPMENT ACT

TThe Federal Sustainable Development Act (S.C. 2008, c. 33) provides the legal framework for a Federal Sustainable Development Strategy (FSDS). Sustainable development is defined within the Act as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Government of Canada, 2021; Government of Canada , 2017). This statement is directly linked to what is known by many Indigenous peoples as the Seven Generations Principle: "decisions we make today should result in a sustainable world seven generations into the future" (ICTINC, 2020).

The FSDS includes "goals, targets, an implementation strategy for each target, and a minister responsible for meeting each target" in its administrative structure. Although this Act does not explicitly mention waste or demolition at all (Government of Canada, 2021), its first sustainable development principle lays the foundation for discussions of CRD waste, stating that the "efficient use of natural, social and economic resources" must be integrated into all decision making (Government of Canada, 2021).

CANADIAN ENVIRONMENTAL PROTECTION ACT

In 1989, the Canadian Environmental Protection Act (CEPA, 1999)—one of the paramount Canadian environmental laws—was created. This Act protects the environment as well as the health and wellbeing of Canadians, with a focus on preventing pollution and addressing exposure to dangerous chemicals. Again, CRD is not considered hazardous and is not specifically mentioned in this Act; however, if not disposed of correctly, CRD does pose a threat to human health (Canada n.d.). Very recently, it has been proposed through Bill C-28 that updates should be made to CEPA, incorporating 35 new recommendations that would include the recognition of peoples' right to a healthy environment (House of Commons, 2021, p. 78; Taylor, 2021). (The Canadian Environmental Protection Act, 1999 (CEPA 1999), 2017).

THE CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT

The Canadian Council of Ministers of the Environment (CCME) is composed of environment ministers from the federal, provincial, and territorial governments. They all work together to improve waste reduction policies and practices across Canada, among other objectives. In 2019, they produced the Guide for Identifying, Evaluating and Selecting Policies for Influencing Construction, Renovation and Demolition Waste Management. The comprehensive 151-page guide covers strategies to assess, prioritize, and evaluate policy for CRD waste reduction (CCME, 2019). This is an integral asset for all levels of government seeking to move towards CE with their CRD policy approach. Much of the data presented in this guide, as well as its frameworks and concepts, were foundational for this project.

THE ENVIRONMENTALLY RESPONSIBLE CONSTRUCTION AND RENOVATION HANDBOOK

Produced by the private sector for Public Works and Government Services, The Environmentally Responsible Construction and Renovation Handbook addresses environmental concerns attached to construction and renovation, providing examples and strategies for industry to implement sustainable construction and renovation practices (Public Works and Government Services Canada, 2001). This document is mentioned within other government and related industry documents, but occasionally links to a broken or missing webpage. It is also hard to find online just by using the title as a search term. Though the document is comprehensive, and contains countless useful strategies and concepts, it is likely outdated—and at 179 pages, it is not easily digestible or accessible for a public audience, many whom may find it most useful.

THE CIRCULAR ECONOMY AT THE FEDERAL LEVEL

CE is not often mentioned in public strategies, and never mentioned in related law at the federal level of the Canadian government. A CE landing page providing a high-level definition on Canada.ca leads to four simple high-level informational pages (Canada, n.d.b). The "Get Involved" webpage lists six actions, encouraging individuals to change their consumption behaviours, and links out to the related "Zero Plastic Waste" landing page. The "Canadian Businesses" page defines—again, at a very high level—what circular design manufacturing can be, along with approaches to recycling and waste reduction.

Yet there is some further evidence of CE activity at the federal level online. An event landing page shows that Canada is hosting the 2021 World Circular Economy Forum, the first in North America (World Circular Economy Forum 2021, n.d.). On April 16, 2021, the Federal Economic Development Agency for Southern Ontario announced that the federal government would be providing $5 million dollars to support the creation of 400 CE jobs in the food and environment sectors, and to develop a Circular Opportunity Innovation Launchpad (COIL) (Canada, 2021).

It is clear that CE in the CRD industry specifically is still nascent in Canada, in comparison to some more established European nations, and conversation around CE is currently addressing a broad range of industries and seldom prioritizes CRD waste. Nevertheless, CE is beginning to emerge in Canada and has the potential to take a more prominent role in policy and public discourse.

The Provincial Goverment

Provincially, the Ontario government delivers regulation and policy frameworks to municipalities, which inform waste management operations like approvals, licensing, and monitoring. The core planning policies that impact municipal growth are the Planning Act, the Provincial Policy Statement (PPS), and the Growth Plan. The graphic representation of the Land-Use Planning System represents the way that different land-use policies and procedures interact in Ontario. The Planning Act guides the Policy Statement and the Growth Plan, which set out clear objectives and guidelines which the City of Toronto must abide by. This section explores what the Province's policies and programs say, or do not say, about CRD waste in relation to development.

LAND-USE PLANNING SYSTEM IN ONTARIO

Graphic translated from (Torrie et al., 2018)

THE PLANNING ACT

The Planning Act serves six main functions, including: 1) the promotion of sustainable economic development; 2) the provision of a land-use planning system led by policy; 3) the integration of provincial and municipal planning decisions; 4) the provision of a planning process; 5) encouragement of co-operation and co-ordination; and 6) recognition of the authority and accountability that the municipal council hold with regard to planning (Planning Act, R.S.O. 1990, c. P.13, 2021). Relating to CRD waste and growth, at a high-level, matters of provincial interest include the adequate provision and efficient use of waste management systems and the minimization of waste. Under the section "Site Plan Requirements," there is mention of the need for waste management plans to be included in the future built form—such as placement of waste and recycling receptacles, as well as storage for larger residential builds. However, no CRD waste-related matters are of explicit concern to the Province under this Act.

The Act also states that a municipality has the ability by law to designate any area in its bounds as a "Demolition Control Area" (Planning Act, R.S.O. 1990, c. P.13, 2021). This means that without a demolition permit granted by the City, demolition cannot happen; City Council thus has the powerful ability to refuse to issue permits for residential properties. Under the Act, permission to demolish may be granted under the condition that a new structure be built within a two-year timeframe. Importantly, there is no proactive stance taken to reduce waste in the Planning Act.

PROVINCIAL POLICY STATEMENT

The Provincial Policy Statement (PPS) gives direction on matters of provincial interest in relation to land use planning and development, and sets the foundation for regulation and minimum standards—all of which is done in coordination with municipalities. In the PPS, "resource" is a term used broadly, but can be generally understood as: land, structures, water, and minerals. It might also be interpreted to incorporate building materials.

The PPS includes a specific waste management section that, like the Planning Act, addresses the need for waste management systems for receiving and accommodating volumes of waste that meet the needs of the present and the future. These systems are required to "facilitate, encourage and promote reduction, reuse and recycling objectives"; however, the PPS does not specify that waste-reduction efforts be adopted during the development of new infrastructure (Provincial Policy Statement, 2020). The general phrasing of the PPS certainly leaves room for various interpretations.

THE GROWTH PLAN

The Places to Grow Act states that "The Growth Plan"—A Place to Grow, Growth Plan for the Greater Golden Horseshoe—may address land supply for residential, employment, and other uses. The Growth Plan is an implementation framework by the Province to plan for growth in ways that support economic prosperity, protection of the environment, and a high quality of life for residents (Ontario, n.d.). This document outlines strategies for municipal waste management planning, among many other environmental and sustainability factors (Ontario, 2020).

The Growth Plan addresses the need for wastewater management throughout the document, but does not reach solid waste management until page 50. The first mention of "waste management" is within the Culture of Conservation section, which outlines what municipalities are required to develop and implement within their official plan policies, as well as other strategies to address conservation. Under this section, the municipality is required to—where appropriate—enhance and create a plan for waste reduction, reuse, and diversion. Directly related to CRD, municipalities must promote building conservation and adaptive reuse, including the reuse and recycling of CRD materials.

In the Growth Plan, waste management initiatives should be considered in a long-term, regional planning context in collaboration with neighbouring municipalities. Under the Climate Change section, upper and single-tier municipalities like Toronto are to develop policies in the official plans which identify actions to reduce GHG emissions and protect the environment. Municipalities are encouraged to, but not required to, track and inventory emissions and climate impact data for buildings and waste management, among other items.

BYLAW 103/94

Under the Ontario Environmental Protection Act (R.S.O. 1990, c. E.19), Bill 103/94: INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL SOURCE SEPARATION PROGRAMS regulates the development of source separation programs for non-residential purposes (Canlii, 2011). Though the bylaw covers multi-unit residential buildings, including the need to offer source separation programs for waste generated at the building, it does not explicitly cover CRD waste.

In Bill 103/94, there is direct mention of regulations for large construction and demolition waste for demolition projects that are at least 2,000 square metres (whereas a typical single detached home is approximately 200 square metres). This large demolition project waste section specifically requires source separation for just brick, cement, cardboard, drywall, steel, and wood (Canlii, 2011). There is no mention of glass, plastics, appliances, roofing asphalt, or metals other than steel—all of which make up significant portions of CRD waste.

CITY OF TORONTO ACT

The City of Toronto Act is a framework of broad powers which relate to the public interest and needs of the City that the City is granted by the province (City of Toronto Act, 2020). Under this act, the City, for its own purposes, may exercise its powers with respect to waste management. The City is also permitted, for the purpose of information gathering, to conduct waste disposal tests through obtaining land samples or extracts.

The Municipal Goverment

The City of Toronto is a creature of the Province, meaning that its power to create policy is granted by the Province through the City of Toronto Act. There are a number of policies which dictate how growth and development are permitted, as well as how waste management is handled. The City operates seven Waste Transfer Stations and many drop-off depots where residents can dispose of items (City of Toronto, n.d.). Many privately owned waste management companies are permitted to operate within the City and offer private collection services.

OFFICIAL PLAN AND ZONING BY-LAWS

The Planning Act requires the City to have an Official Plan (OP). This is a legal document that outlines the policies and objectives for the future of land use in the City (Lintern, 2019). The Planning Act gives authority to the City through the ability to create zoning by-laws (ZBL), which are laws that regulate the use and development of buildings and land—stating the types of uses that are permitted on land, and how properties are permitted to be developed (e.g., lot size, setbacks, height form, etc.).

To change the use or form of the land in any significant way requires amendments to both the OP and the ZBL (Lintern, 2019). These changes would necessitate extensive plans and forms, including additional information and studies such as an energy strategy, heritage impact statement, and natural heritage impact study, among others. Decisions about changes are determined through a process that involves community input and ultimately a decision by City Council.

This amendment process creates an opportunity to re-examine the required documents, information, and studies to include waste management and reduction plans for demolition and construction phases. Much like tree protection and an energy strategy are central features of environmental protection, waste should be instated as an essential factor in the development of buildings and land (City of Toronto, n.d.).

BUILDING AND DEMOLITION PERMITS

Building permits function largely to ensure that safety is a priority and that changes, growth, and development requirements set by the City and guided by the Province are met (City of Toronto, n.d.a). The building permit application process covers new builds, major remodels and renovations, and additions. The process follows five phases:

1) **Determining** if the project complies with existing zoning and laws.
2) **Drafting** plans or hiring a designer to prepare plans and the application.
3) **Applying** for the building and obtaining it.
4) **Starting** construction.
5) **Closing** the permit with a final inspection.

Permits cover specific items like tree protection, heritage conservation, and considerations of environmental or conservation matters related to the Toronto Regional Conservation Authority (TRCA)—which are dependent on whether the building site is close to environmentally sensitive areas, wetlands, and/or shorelines (City of Toronto, n.d.). Throughout the building permit process, the only mention of waste is a single 'tip' that states "do not burn construction waste" (City of Toronto, n.d.a). Information related to waste reduction is not provided to encourage, incentivize, or enforce circular choices at this time. Within this permit-granting process, there is thus an opportunity to include information about demolition waste and material selection in official communications.

SOLID WASTE DIVISION

In short, the Solid Waste Division at the City of Toronto does not mandate anything to do with CRD waste aside from stating that it is prohibited in the residential municipal waste collection stream (Chapter 844). This leaves contractors and home owners to deal with the waste privately, which leaves the management of the waste up to the private waste handler and whatever solution make the most business sense to them.

THE CIRCULAR ECONOMY UNIT

In 2016, the City of Toronto created a new Long-Term Waste Management Strategy (LT-WMS), recognizing that the global and local problem of excessive amounts of waste—in combination with natural resource depletion and pollution—is not sustainable (City of Toronto, n.d. c). As a part of this new strategy, the City has begun "working towards an aspirational goal of zero waste and a circular economy" (City of Toronto, n.d.d), creating the Unit for Research, Innovation & a Circular Economy to advance these efforts. Supporting this initiative, the City's Circular Economy and Innovation (CEI) division is aiming to move Toronto away from a linear take-make-dispose culture through research, pilot programs, and systems design.

TORONTO GREEN BUILDING STANDARDS

The Toronto Green Building Standards (TGS) is the City of Toronto's green building design requirements for new development, which is currently undergoing review for the release of Version 4. Publicly, Version 3 has been active since May 2018 (City of Toronto, n.d.b). The TGS contains several categories for different building types, including low-rise residential, mid- to high-rise residential, and non-residential. It also offers builders a "development charge refund program," which incentivises them to achieve higher than mandatory levels of sustainable performance compliance (City of Toronto, n.d.b). There are four tiers—Tier One being mandatory and Tiers 2, 3, and 4 being voluntary—with increasing requirements and incentives as you advance upwards in number (City of Toronto, 2019). Overall, emphasis of the TGS program is on larger buildings, in order to reduce operational energy consumption on a wider scale.

Requirements for new low-rise residential development include storage for waste including garbage, recycling, and organics, as well as documentation of construction waste in compliance with the Provincial regulation O. Reg. 103/94: Industrial, Commercial and Institutional Source Separation Programs (Canlii, 2011). This documentation of waste may impact the consideration of waste reduction, though it is not regulated and there is no standard for tracking CRD waste within the City. Optional waste reduction measures will contribute to achieving higher Tier levels and increased incentives, e.g., construction waste diversion of at least 75% for Tier 2 and 95% for Tier 3. Tier 2 can also be achieved through reuse and salvaging of the building materials for 50% of the building's surface area (LEED Supplement, 2019). Tier 2 also includes the use of at least 25% sustainable building materials (measured by overall cost of development). With much of the waste reduction and diversion left optional, it is clear that CRD waste is not a focal point of urban development projects in Toronto.

CAGBC AND LEED 4.1

The Canadian Green Building Council (CaGBC) is a not-for-profit organization that advances green building and sustainable development practices (CaGBC, n.d.). The CaGBC holds the Canadian license for the LEED green building rating system (CaGBC, n.d.). LEED is a voluntary green building certification awarded to buildings that meet milestones and targets for specific sustainable metrics that include reducing overall building emissions. In order to achieve LEED certification, a certain number of points across multiple categories must add up to meet a minimum requirement.

Until recently, LEED has not put much emphasis on waste-related carbon reductions. The latest update, 4.1, includes a construction and demolition waste management section in the materials and resources section (LEED, 2021). There is much more importance placed on identifying strategies to reduce and prevent—rather than simply recycling and reusing—waste generated during design and construction. LEED points are given for diverting over 50-75% of waste and, when recycling is required, the facility must be a "regulated facility" (LEED, 2021). This is a sign that change is coming and that leaders in the green building industry, including but not limited to CGBC, are finally recognizing the benefits of reducing CRD waste.

WHAT CAN BE DONE ABOUT THIS?

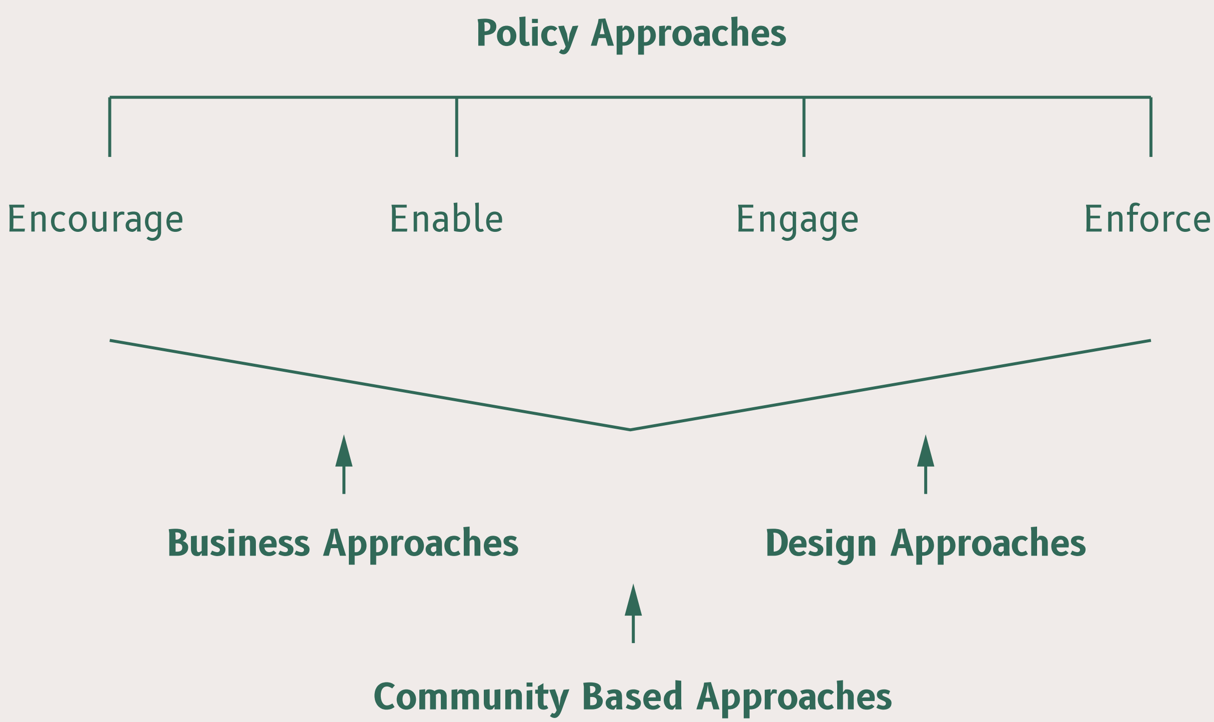
The Changes

- *Policy Levers: Encourage, Enable, Engage, Enforce*
- *Policy and Market Scans*
- *Circular Process Flow Map*

Policy

Policy can encourage, enable, engage, and enforce changes towards a circular economy (Dalhammar et al., 2019; Peck, n.d.). Yet policy is most effective when also joined by innovation and activism from business, design, and community-based approaches, which can reciprocally influence the system and inspire policy adjustments.

Recalling the stakeholder map, other stakeholders like CaGBC, research and development actors, community groups, and non-governmental organizations directly share information with and influence different levels of government. Throughout the development process, various decisions are made that can apply to each of the seven stages in the process flow map. This section outlines possible tools, tactics, and programs that have worked in contexts inside and outside of Toronto at different scales.



Graphic by the author.

Encourage

- Tax cuts
- Subsidies
- Refunds
- Reward schemes

Engage

- Media campaigns
- Voluntary agreements

What can Policy do?

- Remove barriers
- Provide skills
- Provide information

Enable

- Penalties
- Fines

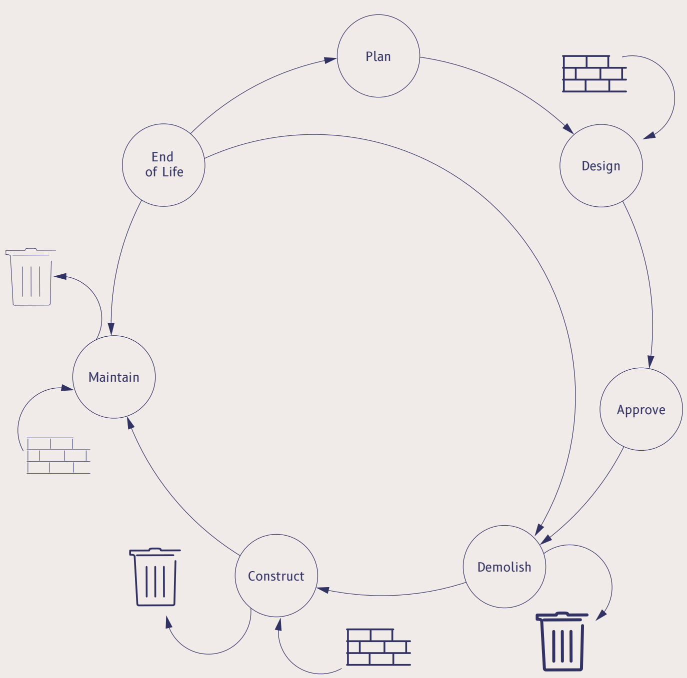
Enforce

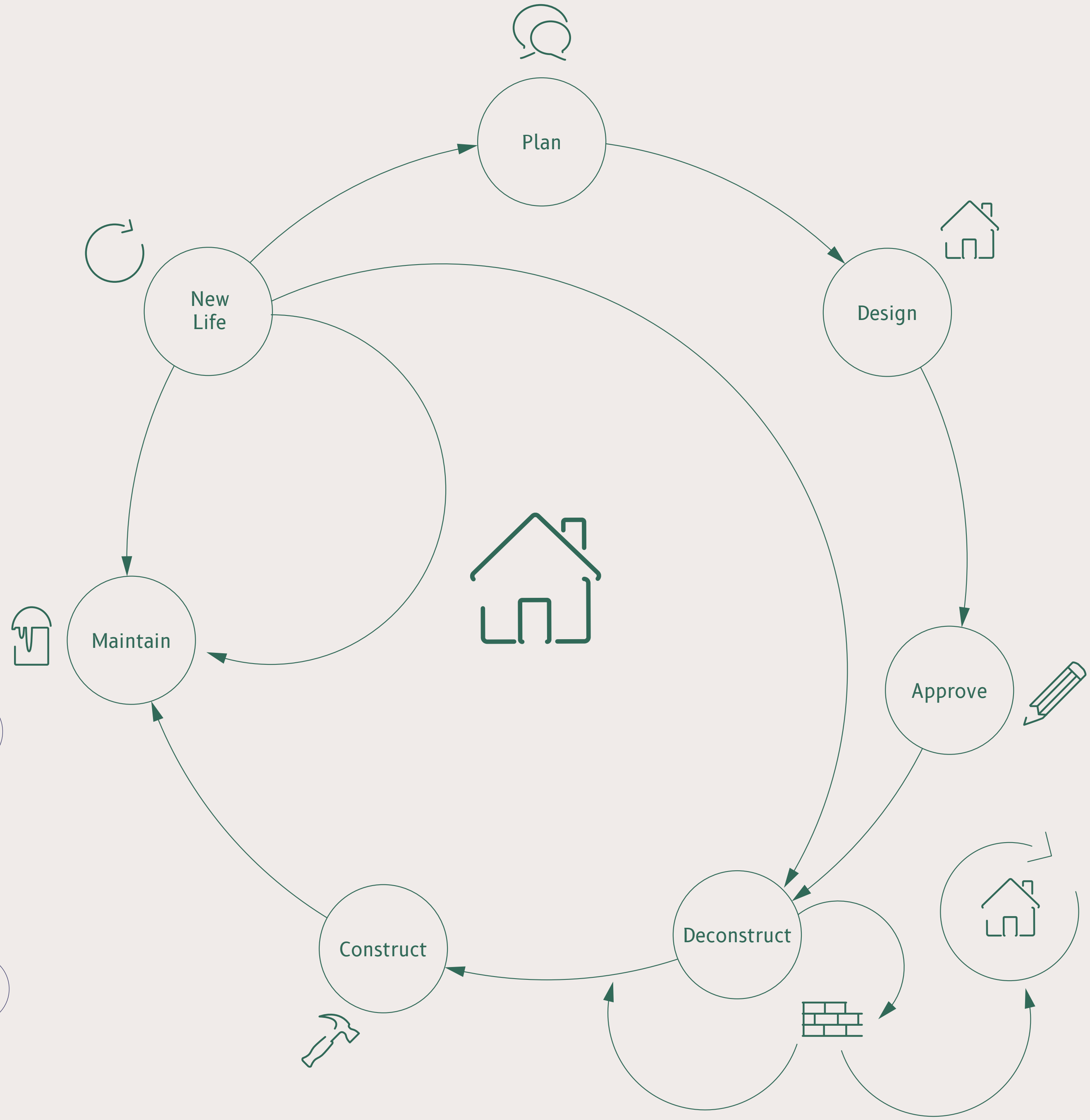
Graphic representation created by the author with information from [Dalhammar et al., 2019; Peck, n.d.]

THE CHANGES

Circular Process Flow Map

For comparison, below is the previously drawn flow map, which shows where materials are brought in and waste exits. Notable changes to the process include rethinking the "demolition" phase as a "deconstruction" phase, and reinterpreting "end of life' as "new life."





Graphic developed by author with inspiration from [Ali Akhtar, Ajit K. Sarmah, 2018, Foster 2019]

THE CHANGES: DESIGN

Circular Product Design

Circular product design can include any methods which find innovative ways to design waste out of a system through slowing, closing, and narrowing “loops” within the circularity model. This is achieved by making design choices that increase durability, repairability, recyclability, and reusability (Bocken et al., 2016).

RECYCLABILITY

Truly circular products are recyclable—able to be recycled and reused after their intended use has been fulfilled. A product can only be considered recyclable if one third of the population can access facilities or drop-off points for processing it (Public Works and Government Services Canada, 2001). Recycled products are a great alternative to new materials; however, many recycled items are not designed to be recycled again and again, and thus only slow linear streams rather than create closed loop product life-cycles. Products made of fewer materials and less adhesives are much easier to recycle (Public Works and Government Services Canada, 2001).

DURABILITY

Durable products that are made well and stand the test of time require less maintenance and less replacing (Public Works and Government Services Canada, 2001). Manufacturers’ warranties help measure durability, but many warranties are not designed to be transparent to consumers. As such, purchasing products with a lifetime warranty are only considered a durable solution if the warranty is navigable (Public Works and Government Services Canada, 2001). There are currently testing procedures under development which would help to standardize warranties and durability claims, making warranties effective for environmental impact reductions (Public Works and Government Services Canada, 2001).

SERVICE DESIGN

Product-service systems (PSS)—business models that integrate both product and service value offerings—are important components to making circular product design successful (Milios, 2018). Without considering the user of the product and their role in maintaining a closed loop over time, the circularity of the product will be lost; no matter how well it is designed, it will not remain part of a circular economy.

Governments have a significant role in promoting this approach and encouraging innovation in this sector (Milios, 2018). Logistics and public education are key factors in ensuring that circular business models are successful. It is important to have a well-developed logistics plan to effectively manage how materials will be retrieved, transported, and processed after use. For the system to work well, consumers and other key stakeholders—like construction and demolition workers—must be involved in keeping materials in the loop, rather than sending things to landfill. As such, education is essential for informing consumers of the process, gradually changing their behaviour to ensure active participation in the new system.

CIRCULAR PRODUCT SWAPS

Though many of these circular products are available in Canada, there are often barriers including the need to ship circular products from Europe where they are more prevalent, and of course affordability. Encouraging circular product design locally and nationally will improve access and affordability, as well as reduce emissions from shipping material overseas.

CARBON STORING MATERIALS

Not only are these materials renewable, but they are also able to remove and sink carbon from the atmosphere. Carbon drawn is in and stored in the plants as they are grown. Materials that store carbon include: timber, wood fiber board, cork, ReWall, waste textiles, cellulose, straw, mycelium, rice hulls, bamboo/BamCore, coconut coir, hemp OSB and others (NESEA Building Energy Boston 2019 Keynote- Carbon Drawdown Now, 2019).

EXAMPLE: SPRAY FOAM INSULATION VS. RECYCLED DENIM INSULATION

Though spray foam insulation has been touted as a sustainable insulation option in terms of efficiency and effectiveness for reducing wasted heat and energy, though, if not installed properly, its efficacy significantly decreases (Alter, 2019). Spray foam is also full of chemicals and packed with embodied carbon (Alter, 2019). It also ranks low for affordability and high for health hazards (Guidance for Specifying Healthier Insulation and Air-Sealing Materials, 2019). Once spray foam has been applied, it is permanent. Which may sound like a good thing, but any material it adheres to loses any possibility of being safely salvaged or recycled.

Denim insulation is a circular product which reduces the fashion industry's waste by diverting clothing items like jeans from landfill. Batts of denim insulation behave much like traditional fiberglass batts and not require adhesive to install which makes them easy to install, remove and re-use. Cotton is a natural and renewable fabric and does not contain toxins like formaldehyde, like fiberglass does. It is more expensive when compared to fiberglass. Using denim insulation helps add points when working towards a LEED certified building (Fischer, 2015; Guidance for Specifying Healthier Insulation and Air-Sealing Materials, 2019).

LEED CERTIFIED PRODUCTS

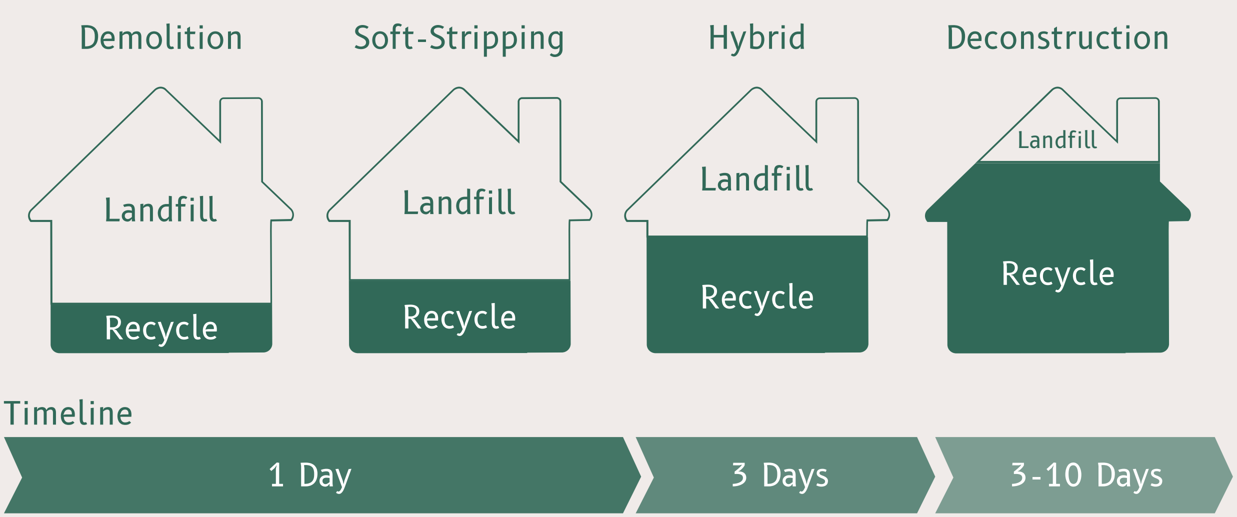
To earn LEED certification points, there are specific LEED-compliant products that can be chosen instead of traditional materials. A helpful product guide tailored to general contractors has been compiled by the private company Green Badger. The guide covers a multitude of products—from insulation and flooring to paint, doors, and more (Linstroth & Badger, n.d.)..

Deconstruction

An alternate concept to the demolition of existing buildings is "deconstruction"—which denotes that the manual removal of an existing structure's materials should be done with care. Though it may be more time-consuming, deconstruction helps to preserve potentially salvageable materials like drywall, lumber, wiring, pipes, and ceiling panels (Public Works and Government Services Canada, 2001).

The City of Vancouver has instated a Green Demolition By-Law which, to be granted a building permit, requires buildings of a certain age to salvage or divert a significant portion of the building's weight from landfill (City of Vancouver, 2020; City of Vancouver, 2018). Huge amounts of waste reduction—e.g., at least 75% of a building by weight for certain buildings under this By-Law—are not the only benefit. Property owners are also able to qualify for significant deposit refunds, as well as provincial and federal tax credits, which result in the average deconstruction project being cheaper than a traditional demolition (Unbuilders, n.d.). A local Vancouver business, Unbuilders, is leading the way for deconstruction in Canada, finding innovative ways to connect their construction and deconstruction work to salvage markets to increase jobs and profit (Unbuilders, n.d.). Throughout British Columbia, many other municipalities have begun to implement similar by-laws. There are also a number of programs and projects in various states across America, initiated by the non-profit Delta Institute—who has produced a comprehensive guide for deconstruction based on their experience (Delta Institute, 2018).

DEMOLITION METHODS, TIME INVESTMENT, AND WASTE DIVERTED

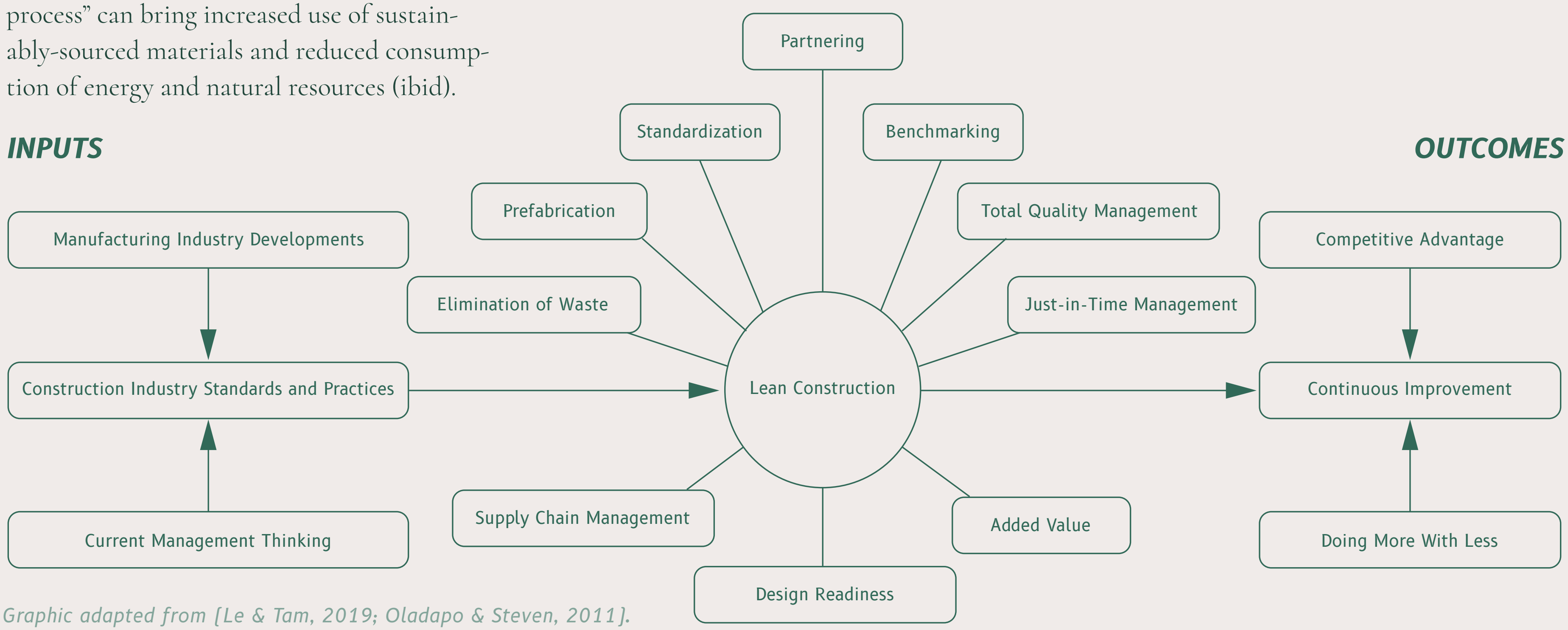


Graphic by the author, with information and inspiration from [Delta Institute, 2018; McDonald, 2018].

Lean Construction

Lean construction is a borrowed concept from other industries, and can essentially can be understood as a project management philosophy that targets quality and efficiency (Oladapo & Steven, 2011). Lean and sustainable construction both focus on the removal of waste and overall cost reduction in the building process (Le & Tam, 2019; Oladapo & Steven, 2011). Making the construction process a "cyclic process" can bring increased use of sustainably-sourced materials and reduced consumption of energy and natural resources (ibid).

The lean approach identifies "seven types of waste: overproduction, overstocking, excessive motion, waiting time, transportation, extra-processing and defects" (Le & Tam, 2019; Oladapo & Steven, 2011). Reducing this waste is achieved through improved organizational and supply chain communication. The basics of lean construction are "waste reduction, process focus in production planning and control, end customer focus, continuous improvements, cooperative relationship, and systems perspective" (Le & Tam, 2019; Oladapo & Steven, 2011). The graphic below illustrates the inputs of the construction process, the principles of lean construction, and the outcomes.



Graphic adapted from [Le & Tam, 2019; Oladapo & Steven, 2011].

Modularity

Modular housing is factory built with a focus on precision, resulting in speedy production, high quality, and energy-efficient construction (Levitt, 2014). The prefabrication of modular housing and home additions can reduce waste, emissions, noise pollution, construction-related traffic, and road closure—due to the majority of the fabrication time being offsite (Norman & Bray, 2020). Modular housing can also be cheaper for similar reasons, which makes it not only a sustainable option but also a more affordable one (Levitt, 2014).

Though there are some limitations to modularity, depending on the choices made by the designer or user, there is still potential for modular construction as a sustainable construction option (Sonego et al., 2018). See the graphic below for a high-level life-cycle analysis of the benefits and limitations of modularity.

BENEFITS AND LIMITATIONS OF MODULARITY IN EACH STAGE OF THE PRODUCT LIFE CYCLE

	Production	Use	Disposal
Benefits	Material Customization Supply Chain Manufacture Obsolescence R&D	Maintenance Repairability Upgrades Functionality Services	Recycling Reuse Remanufacture
Limitations	Methods Choice Limits Innovation Increases development time and complexity	User acceptance and perception Performance problems (overdesign, faulty interfaces) Diversity of use scenarios and user behaviour Promotes obsolescence	Concrete evidence Lack of company support

Adapted by the author based on: (Sonego et al., 2018)

Sharing Economy

Markets for salvaged materials and products can extend their use, preventing or slowing resources from ending up in the landfill. This is often accomplished through second-hand stores like Habitat for Humanity's Restore, or through alternative avenues like trading, donating, and sharing within communities (Prendeville et al., 2018).

These collective avenues for sustainability are associated with the "sharing economy," which is an alternative to the current profit-driven capitalist model (Richardson, 2015). Much like the circular economy inspires us to think differently about materials, the sharing economy is a new way of thinking about what the possession of materials means. These sharing communities have been made more effective through digital platforms, which allow peers to exchange goods and services freely without currency (Richardson, 2015). Importantly, the sharing economy does not only promote the exchange of second-hand goods, but also encourages the development of repair skills that help extend the life of products and materials (Prendeville et al., 2018).

A 'Free Store' in Cornwall, Ontario has diverted more than four tonnes of waste from landfill in just 5 months.

(Vandermeer, 2021).

One interesting example of the potency of the sharing economy is a "Free Store" in Cornwall, Ontario, which has diverted more than four tonnes of waste from landfill in just five months (Vandermeer, 2021). It was started when the City of Cornwall provided a space at the local landfill to display salvageable goods and supplies for public consumption (Vandermeer, 2021). The city-owned landfill is estimated to have a life expectancy of 12 years, after which it will have to close and can no longer take more waste (Vandermeer, 2021). Thus, this simple Free Store program is a win-win for both the city and residents. Many other towns across Ontario have reportedly reached out to the township to inquire about how they set this up and maintain it, in hopes of starting their own.

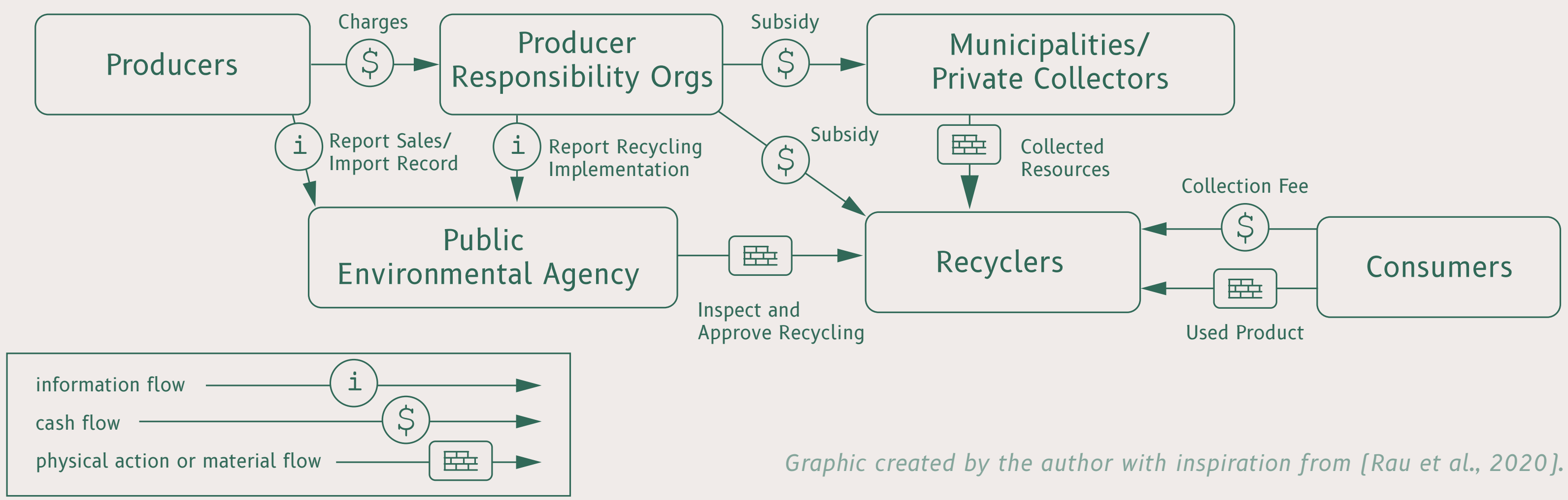
THE CHANGES: NEW LIFE

Extended Producer Responsibility

The province of Ontario has several programs that place the responsibility of waste diversion and end-of-life handling on producers (Waste Management, n.d.). These programs cover items like tires, electronics, hazardous waste, batteries, and bottle deposits (Waste Management, n.d.).

These types of programs and mandates leverage the concept of extended producer responsibility (EPR)—which is applied in practice as a policy or program that puts the cost (i.e., "producer pays") and often coordination of handling waste back into the hands of the original producer (Stewardship Ontario, n.d.). In their Guide for Identifying, Evaluating and Selecting Policies for Influencing Construction, Renovation and Demolition Waste Management, the CCME recommends that governments look into creating producer responsibility programs for flooring, drywall, window glass, brick, asphalt roofing, and engineering/treated wood (CCME, 2019).

Mandatory and voluntary EPR can encourage producers to re-design their products to make them easier to retrieve, reuse, and recycle (Rau et al., 2020). While these programs are not always mandatory, this practice can be a wise and appealing business choice for producers—with the potential to save money by salvaging materials, as well as the ability to market their business as a sustainable option, setting them apart from competition. EPR policies require considerable systems changes, such as the example shown below. Fees, subsidies, and inspections are used to ensure that materials are handled responsibly by producers and consumers (Rau et al., 2020).



Graphic created by the author with inspiration from [Rau et al., 2020].

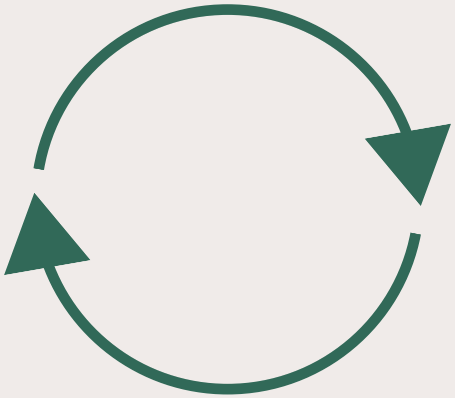
WHAT'S NEXT?

The Future

- *Recommendations*
- *Towards a Circular Economy*

THE FUTURE

Towards a Circular Economy



SOME RECOMMENDATIONS FOR THE CITY OF TORONTO:

- Develop or facilitate programming to train industry on deconstruction practices and designate funding incentives.
- Provide waste reduction or deconstruction information and encourage the selection of circular product options early to demolition and building permit seekers.
- Create a local, circular product and practitioner roster to highlight businesses that are working towards waste reduction.

On the global scale, policy makers, regulating and enforcing bodies, and waste generators must work together to reduce carbon emissions across industries—in order to ensure that there is a chance for a resilient future. Without intentional, strategic action and design, there is no stopping the crushing amount of CRD waste that is on the horizon.

CRD waste is generated for a multitude of reasons, including changing needs, potential profit, and aging infrastructure. Knowing that the future of sustainable growth cannot simply remain as basic as reducing operational emissions, the embodied carbon and impacts on the environment and land-use from unmonitored CRD waste must be reduced. There is plenty of research to back up why moving towards a circular economy would achieve significant waste prevention and reductions in the City of Toronto, as well as other cities globally.

To undertake action that shifts the current take-make-dispose system towards a circular economy system, several coordinated strategies must be leveraged to address the many reasons that waste is generated. Policies need to evolve to explicitly include regulations around construction, renovation, and demolition waste. Education for public and industry stakeholders about the negative impacts of CRD waste, and strong communication on the benefits of circular solutions, is badly needed—particularly at strategic, critical times when decisions about design and demolition are being made.

Providing the right information early in the process will enable decision makers to prevent and reduce waste through circular design, salvaged material selection, and creative reuse. This is a shared responsibility among stakeholders; however, ultimately, producers must be held accountable for their negative impacts. Those who generate the most CRD waste must evolve to meet the increasingly pressing sustainability needs of present and future generations.

WHAT RESOURCES WERE USED?

References

Resources:

1. Akhtar, A., & Sarmah, A. K. (2018). Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective. Journal of Cleaner Production, 186, 262–281. https://doi.org/10.1016/j.jclepro.2018.03.085

2. Alnajem, M., Mostafa, M. M., & ElMelegy, A. R. (2021). Mapping the first decade of circular economy research: A bibliometric network analysis. Journal of Industrial and Production Engineering, 38(1), 29–50. https://doi.org/10.1080/21681015.2020.1838632

3. Alter, L. (2019, March 1). Why You Shouldn't Choose Spray Foam Insulation Over Fiberglass. Treehugger.Con. https://www.treehugger.com/why-you-shouldnt-choose-spray-foam-insulation-over-fiberglass-4858208

4. Application Support Material: Terms of Reference. (n.d.). Toronto.Ca. Retrieved April 10, 2021, from https://www.toronto.ca/city-government/planning-development/application-forms-fees/building-toronto-together-a-development-guide/application-support-material-terms-of-reference/?accordion=energy-strategy

5. Apply for a Building Permit. (n.d.). Toronto.Ca. Retrieved April 15, 2021, from https://www.toronto.ca/services-payments/building-construction/apply-for-a-building-permit/

6. Armani, A. (2020, April 23). What Are the Best Home Improvements For Resale (2020). T. https://torealestateagent.com/best-home-improvements-for-resale/

7. Armstrong, P. (2021, April 2). Record-high lumber prices add as much as $30K to the cost of building a house. CBC News. https://www.cbc.ca/news/business/lumber-prices-covid-19-cost-of-housing-1.5973416?fbclid=IwAR1Z8PpEMRPR-FKvMx4PzdVK-3VENCXbqJ85r1xOPjrLel78v-dloHmK6Y4

8. Bailly, J. (2020, May 13). Did It Take a Pandemic to Get Serious About Beauty Waste? Allure. https://www.allure.com/story/beauty-industry-packaging-waste

9. Bamforth, I. (2011). Edward R Tufte – the 'Information Man': A profile of America's leading proponent of effective strategies for seeing and showing. British Journal of General Practice, 61(593), 737–740. https://doi.org/10.3399/bjgp11X613179

10. Benyus, J. M. (2008). Biomimicry: Innovation inspired by nature (repr). Harper Perennial.

11. Berg, A., Granskog, A., Lee, L., & Magnus, K.-H. (n.d.). Fashion on Climate. Mckinsey.Com. https://www.mckinsey.com/industries/retail/our-insights/fashion-on-climate#:~:text=Fashion%20makes%20a%20sizeable%20contribution,percent%20of%20the%20global%20total.

12. Blais, P. (2010). Perverse Cities: Hidden Subsidies, Wonky Policy, and Urban Sprawl. UBC Press.

13. Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

14. CaGBC. (n.d.). About Us. Canada Green Building Council. https://www.cagbc.org/CAGBC/About_Us/CAGBC/AboutUs/About_Us.aspx?hkey=2259347d-6d16-4417-ba6c-a442711f95a1

15. Canada. (n.d.-a). Guide to understanding the Canadian Environmental Protection

Act: Chapter 10. Canada.Ca. https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/guide-to-understanding/chapter-10.html

16. Canada. (n.d.-b). Managing and reducing waste. Canada.Ca. https://www.canada.ca/en/services/environment/pollution-waste-management/managing-reducing-waste.html

17. CANADA National Reporting to CSD-18/19 Thematic Profile: Waste Management. (2019). United Nations. https://sustainabledevelopment.un.org/

18. Canada. (n.d.). Reducing municipal solid waste. Canada.Ca. https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/municipal-solid/reducing.html

19. Cavaleiro de Ferreira, A., & Fuso-Nerini, F. (2019). A Framework for Implementing and Tracking Circular Economy in Cities: The Case of Porto. Sustainability, 11(6), 1813. https://doi.org/10.3390/su11061813

20. Checkland, P., & Poulter, J. (2010). Soft Systems Methodology. In M. Reynolds & S. Holwell (Eds.), Systems Approaches to Managing Change: A Practical Guide (pp. 191–242). Springer London. https://doi.org/10.1007/978-1-84882-809-4_5

21. City of Toronto Act, 2006, S.O. 2006, c. 11, Sched. A, (2020). https://www.ontario.ca/laws/statute/06c11

22. Dalhammar, C., Peck, D., Orlov, D., Machacek, E., Gillabel, J., Richter, J. L., Nussholz, J., Vrancken, K., Whalen, K., Modis, K., Milios, L., Messing, M., Bocken, N., Tojo, N., Davris, P., Peck, P., Manshoven, S., Sfez, S., Lindhqvist, T., & Palgan, Y. V. (2019). Circular Economy – Sustainable Materials Management A COMPENDIUM BY THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS (IIIEE) AT LUND UNIVERSITY. 45.

23. Deconstruction & Building Material Reuse: A Tool for Local Governments & Economic Development. (2018). Delta Institute. https://delta-institute.org/wp-content/uploads/2018/05/Deconstruction-Go-Guide-6-13-18-.pdf

24. Drop-Off Depots. (n.d.). Toronto.Ca. Retrieved April 18, 2020, from https://www.toronto.ca/services-payments/recycling-organics-garbage/drop-off-depots/

25. Environment and Climate Change Canada. (2020, October 7). Canada one-step closer to zero plastic waste by 2030. Canada.Ca. https://www.canada.ca/en/environment-climate-change/news/2020/10/canada-one-step-closer-to-zero-plastic-waste-by-2030.html

26. Etobicoke Centre: City of Toronto Ward Profiles. (2018). City of Toronto. https://www.toronto.ca/wp-content/uploads/2018/09/8f45-City_Planning_2016_Census_Profile_2018_25Wards_Ward02.pdf

27. Fischer, N. (2015, October 8). Denim Insulation: The Good And The Bad. BuildDirect.Com. https://www.builddirect.com/blog/denim-insulation-the-good-and-the-bad/#:~:text=Denim%20and%20cotton%20scraps%20from,it%20out%20of%20the%20landfills.&text=As%20long%20as%20people%20wear,-making%20it%20a%20renewable%20product

28. Florez Ayala, D. H., & Alberton, A. (2020). Urban Living Labs: Sustainability Transitions Towards Circular Cities. Urban Living Labs: Sustainability Transitions Towards Circular Cities

29. Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. Resources, Conservation and Recycling, 152, 104507. https://doi.org/10.1016/j.resconrec.2019.104507

30. Government of Canada. (2021, April 16). Federal Sustainable Development Act (S.C. 2008, c. 33). https://laws-lois.justice.gc.ca/eng/acts/F-8.6/

31. Government of Canada invests in Canada's first circular economy focused accelerator and test platform. (2021, April 16). Canada.Ca. https://www.canada.ca/en/economic-development-southern-ontario/news/2021/04/government-of-canada-invests-in-canadas-first-circular-economy-focused-accelerator-and-test-platform.html?wbdisable=true#wb-cont

32. Green Blue. (n.d.). RELOOP: WHAT IS MIXED WASTE PROCESSING OR "ALL IN ONE/DIRTY MRF" RECYCLING? Greenblue.Org. Retrieved April 10, 2021, from https://greenblue.org/reloop-what-is-mixed-waste-processing-or-all-in-onedirty-mrf-recycling/

33. GREEN DEMOLITION BY-LAW NO. 11023. (2020). City of Vanvoucer. https://bylaws.vancouver.ca/11023c.pdf

34. Green Demolition By-law Update. (2018). https://council.vancouver.ca/20180516/documents/pspc2c.pdf

35. Guidance for Specifying Healthier Insulation and Air-Sealing Materials. (2019). Energy Efficiency For All. https://www.energyefficiencyforall.org/resources/guidance-for-specifying-healthier-insulation-and-air-sealing-materials/

36. Guide for Identifying, Evaluating and Selecting Policies for Influencing Construction, Renovation and Demolition Waste Management. (2019). Canadian Council of Ministers of the Environment(CCME).

37. Healing, D. (2020, August 14). Record lumber prices adding thousands of dollars to new home building costs. https://globalnews.ca/news/7276005/lumber-prices-2020-home-building-costs/

38. Housing Report: COVID-19 to Dent Renovation Spending, a Vital Driver of Canadian Economic Activity. (2020). Altus Group.

39. How Toronto Real Estate Is Shifting From 'Fixer-Upper' Flips To 'Tear Down' New Construction. (2019, November 7). https://www.urbaneer.com/blog/shift_from_fixer-upper_flipping_to_new_construction_luxury_homes_toronto

40. Hunziker, R. (2021, March 6). Climate crisis. https://www.thenews.com.pk/print/799662-climate-crisis

41. Industrial, Commercial and Institutional Source Separation Programs, no. O Reg 103/94 (2011). https://www.canlii.org/en/on/laws/regu/o-reg-103-94/latest/o-reg-103-94.html

42. Ireland, C. (2021, March 24). Eager sellers, zealous buyers driving up home prices in Toronto. The Globe and Mail. https://www.theglobeandmail.com/real-estate/toronto/article-eager-sellers-zealous-buyers-driving-up-home-prices-in-toronto/

43. Jojola, T. (2013). Indigenous Planning: Towards a Seven Generations model. In Reclaiming Indigenous Planning (Vol. 70). McGill-Queen's University Press.

44. Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. Ecologi-

cal Economics, 143, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

45. Le, K. N., & Tam, V. W. Y. (2019). Lean Principles in Construction. In Sustainable construction technologies life-cycle assessment (p. 321). Elsevier-Butterworth-Heinemann.

46. Levitt, R. (2014). Sustainable Construction in Indian Country: Expanding Affordability with Modular Multifamily Infill Housing. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2563153

47. Linstroth, T., & Badger, G. (n.d.). A TOOL FOR GENERAL CONTRACTORS. 26.

48. Lintern, G. (2019). Toronto Official Plan. City of Toronto.

49. Map the System 2021. (n.d.). Ryerson. Retrieved February 18, 2021, from https://www.ryerson.ca/social-innovation/map-the-system/

50. Map the System Canada 2020. (n.d.a). Map The System. Retrieved April 10, 2021, from https://www.mapthesystem.ca/2020

51. Marquis, C. (2021, April 6). Making Salads Even Greener: Just Salad Is Bringing Zero-Waste Dining Into The Mainstream. Forbes.Ca. https://www.forbes.com/sites/christophermarquis/2021/04/06/making-salads-even-greener-just-salad-is-bringing-zero-waste-dining-into-the-mainstream/?sh=6a1d118514f0

52. Materials and Resources: Construction and Demolition Waste Management. (2021, January 29). Canada Green Building Council - CaGBC. https://www.youtube.com/watch?v=vLaHZ-G-of-g&list=PLpOCmb1QBK8Z9vuArSuhrx-GwKZnpBQ8f5&index=9

53. McDonald, J. (2018, September 4). Residential Deconstruction is on the Rise. Dumpsters.Com. https://www.dumpsters.com/blog/intro-to-home-deconstruction

54. McDonough, W., Braungart, M., & Tantor Media, I. (2008). Cradle to cradle: Remaking the way we make things. Tantor Media, Inc.

55. Meadows, D. H. (1994, October). Dr. Dana Meadows: Envisioning A Sustainable World. UVM Continuing Education. https://vimeo.com/13213667

56. Meadows, D. H. (1999). Leverage Points: Places to Intervene in a System. The Sustainability Institute. http://www.donellameadows.org/wp-content/userfiles/Leverage_Points.pdf

57. Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. (1972). The Limits to Growth: A report for the Club of Rome's Project on the Predicament of Mankind. Universe Books. https://doi.org/10.1349/ddlp.1

58. Meadows, D. H., & Wright, D. (2008). Thinking in systems: A primer. Chelsea Green Pub. //catalog.hathitrust.org/Record/006795909

59. Milios, L. (2018). Advancing to a Circular Economy: Three essential ingredients for a comprehensive policy mix. Sustainability Science, 13(3), 861–878. https://doi.org/10.1007/s11625-017-0502-9

60. Mirabelli, J. (2017, April 25). DenseCity Part 1: Where Toronto Builds Density and Why. Urban Toronto. https://urbantoronto.ca/news/2017/04/densecity-part-1-where-toronto-builds-density-and-why

61. Neptis. (n.d.). Urban Growth Centres. Neptis. Retrieved March 8, 2021, from https://neptis.org/publications/

how-will-growth-be-accommodated/chapters/urban-growth-centres

62. NESEA BuildingEnergy Boston, 2019 Keynote- Carbon Drawdown Now. (2019, March 14). ReelifeProductions.com. https://vimeo.com/328548993

63. NEW BUILDINGS: EMBODIED CARBON. (n.d.). https://architecture2030.org/new-buildings-embodied/

64. Norman, P., & Bray, M. (2020, December 9). Modular building construction: Has its time finally come? Altus Group. https://www.altusgroup.com/services/insights/modular-construction-has-its-time-finally-come/

65. NOTICE PAPER No. 78, House of Commons (2021). https://www.ourcommons.ca/DocumentViewer/en/43-2/house/sitting-78/order-notice/page-11

66. Oladapo, A. A., & Steven, J. (2011). Construction Innovation: The Implementation of Lean Construction towards Sustainable Innovation. 14.

67. Ontario. (n.d.). A Place to Grow: Growth plan for the Greater Golden Horseshoe. Ontario.Ca. Retrieved March 5, 2021, from https://www.ontario.ca/document/place-grow-growth-plan-greater-golden-horseshoe?_ga=2.250821766.1019376219.1563829392-126124738.1554927838

68. Places to Grow Act, 2005, S.O. 2005, c. 13, (2020) (testimony of Ontario). https://www.ontario.ca/laws/statute/05p13

69. Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N., & Ujang, Z. bin. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. Journal of Cleaner Production, 76, 106–115. https://doi.org/10.1016/j.jclepro.2014.04.020

70. Peck, P. (n.d.). Circular Economy—Sustainable Materials Management. Coursera. https://www.coursera.org/learn/circular-economy

71. Planning Act, R.S.O. 1990, c. P.13. (2021). Ontario. https://www.ontario.ca/laws/statute/90p13#BK2

72. Prendeville, S., Cherim, E., & Bocken, N. (2018). Circular Cities: Mapping Six Cities in Transition. Environmental Innovation and Societal Transitions, 26, 171–194. https://doi.org/10.1016/j.eist.2017.03.002

73. Provincial Policy Statement, 2020—Under the Planning Act. (2020). Ontario. https://files.ontario.ca/mmah-provincial-policy-statement-2020-accessible-final-en-2020-02-14.pdf

74. Rau, H., Bisnar, A. R., & Velasco, J. P. (2020). Physical Responsibility Versus Financial Responsibility of Producers for E-Wastes. Sustainability, 12(10), 4037. https://doi.org/10.3390/su12104037

75. Rawcliffe, N. (2008). The 'Tear-Down' Trend. CANADIAN PROPERTY VALUATION MAGAZINE, 52. https://www.aicanada.ca/article/the-tear-down-trend/

76. REPORT TO THE HOUSE OF COMMONS STANDING COMMITTEE ON ENVIRONMENT AND SUSTAINABLE DEVELOPMENT ON THE FEDERAL SUSTAINABLE DEVELOPMENT ACT. (2017). Government of Canada. https://www.canada.ca/content/dam/eccc/migration/main/dd-sd/ded568bb-a8e1-4bdd-8c22-877d14f1c7b5/envi_report_response_june2017.pdf

77. Richardson, L. (2015). Performing the sharing economy. Geoforum, 67,

121–129. https://doi.org/10.1016/j.geoforum.2015.11.004

78. Ritchey, T. (2011). Wicked problems-social messes: Decision support modelling with morphological analysis. Springer-Verlag.

79. Rittel, H., & Webber, M. (1973). Dilemmas in a General Theory of Planning. Https://Urbanpolicy.Net/Wp-Content/Uploads/2015/06/Rittel-Webber_1973_DilemmasInAGeneralTheoryOfPlanning.Pdf, 2, 155–169.

80. Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S. I., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., … Foley, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society, 14(2), art32. https://doi.org/10.5751/ES-03180-140232

81. Scarborough Centre: City of Toronto Ward Profiles. (2018). City of Toronto. https://www.toronto.ca/wp-content/uploads/2018/09/8f47-City_Planning_2016_Census_Profile_2018_25Wards_Ward21.pdf

82. Schools of Thought. (n.d.a). Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought

83. Simonpillai, R. (2021, March 25). Scarborough is the last frontier for affordable Toronto real estate. Now Toronto. https://nowtoronto.com/lifestyle/real-estate/scarborough-is-the-last-frontier-for-affordable-toronto-real-estate

84. Simovic, V. (2019). CANADIAN SMART CITIES: A CASE FOR THE CIRCULAR ECONOMY IN THE AGE OF “SMART” INNOVATION. 194.

85. Sonego, M., Echeveste, M. E. S., & Galvan Debarba, H. (2018). The role of modularity in sustainable design: A systematic review. Journal of Cleaner Production, 176, 196–209. https://doi.org/10.1016/j.jclepro.2017.12.106

86. Special Report: Global Warming of 1.5 oC. (n.d.). IPCC. https://www.ipcc.ch/sr15/

87. Staff. (n.d.). Donella Meadows. Retrieved April 16, 2021, from http://donellameadows.org/staff/

88. Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sorlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. Science, 347(6223), 1259855–1259855. https://doi.org/10.1126/science.1259855

89. Taylor, S. (2021, April 13). A right to healthy environment included in proposed changes to legislation: Wilkinson. Toronto Star. https://www.thestar.com/politics/2021/04/13/a-right-to-healthy-environment-included-in-proposed-changes-to-cepa-wilkinson.html

90. Tear Downs In Toronto: The Growing Trend Continues. (n.d.). Walden. https://waldenhomes.ca/blog/tear-downs-toronto-growing-trend-continues/

91. The Canadian Environmental Protection Act, 1999 (CEPA 1999). (2017, April 6). Canada.Ca. https://www.canada.ca/en/health-canada/services/chemical-substances/canada-approach-chemicals/canadian-environmental-protection-act-1999.html

92. The City of Toronto Zero Emis-

sions Buildings Framework. (2017). City of Toronto; Toronto Atmospheric Fund. https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf

93. The Ellen MacArthur Foundation. (n.d.b). Circular economy general resources map. https://kumu.io/ellenmacarthurfoundation/educational-resources#circular-economy-general-resources-map/key-for-general-resources-map

94. The Environmentally Responsible Construction and Renovation Handbook. (2001). Public Works and Government Services Canada.

95. Toronto Building: Homeowner's Guide to Building Permits. (n.d. a). City of Toronto. https://www.toronto.ca/wp-content/uploads/2017/11/9273-Building-Permit-Guide-WEB.pdf

96. Toronto Green Standard. (n.d. b). Retrieved November 10, 2020, from https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/

97. Toronto Housing Market Analysis: From Insight to Action. (2019). Canadian Centre for Economic Analysis; Canadian Urban Institute. https://www.toronto.ca/legdocs/mmis/2019/ph/bgrd/backgroundfile-140633.pdf

98. Toronto: LEED Supplement, Summary Comparison | Version 3.0 Toronto Green Standard (TGS) High-Rise Residential and Non-Residential Developments & LEED Version 4.0 Building Design and Construction (BD+C) Rating System. (2019). City of Toronto.

99. Toronto's Average property price tops C$1m for the first time. (n.d.). Financial Times. https://www.ft.com/content/f58c3894-d45a-4c32-aa1a-db0bde37f803

100. Torrie, R., Murphy, J., Meyer-MacLeod, J., Jager, M. D., Sullivan, M., Devine, N., Winkelmann, S., & Yuill Herbert. (2018). Community Emissions Reduction Planning: A Guide for Municipalities. https://doi.org/10.13140/RG.2.2.18968.08961

101. Unbuilders. (n.d.). Retrieved April 15, 2021, from https://unbuilders.com/

102. Vandermeer, N. (2021, March 16). "Free store" has diverted more than four tonnes of waste from Cornwall landfill site since November. CTV News. https://ottawa.ctvnews.ca/free-store-has-diverted-more-than-four-tonnes-of-waste-from-cornwall-landfill-site-since-november-1.5349611?fbclid=IwAR3lhYJ11fSNSyvMp5wFS8OrdOA1I5QGK3K51-SkT3W1anc5nukUrO9V2i8

103. Verma, R., & Husain, R. (n.d.). The resilience and strength of the new housing market during the pandemic. Statistics Canada. https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00080-eng.htm

104. Waste management. (n.d.). Ontario.Ca. Retrieved April 15, 2021, from https://www.ontario.ca/page/waste-management

105. Waste Strategy Overview. (n.d.c). City of Toronto. Retrieved March 20, 2021, from https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/overview/

106. What is Extended Producer Responsibility? EPR, Product Stewardship, Industry Stewards and Closed Loops. (n.d.). Stewardship Ontario. https://stewardshipontario.ca/what-is-extended-producer-responsibility/

107. What is Map the System? (n.d.b).

Map The System. Retrieved April 10, 2021, from https://mapthesystem.web.ox.ac.uk/overview

108. What is the circular economy? (n.d. b). Canada.Ca. Retrieved March 22, 2021, from https://www.canada.ca/en/services/environment/conservation/sustainability/circular-economy.html#wb-cont

109. What is the Seventh Generation Principle? (2020, May 30). ICTINC.Ca. https://www.ictinc.ca/blog/seventh-generation-principle

110. Working Toward a Circular Economy. (n.d.d). Toronto.Ca. Retrieved March 20, 2021, from https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/working-toward-a-circular-economy/

111. World Circular Economy Forum 2021. (n.d.). Canada.Ca. Retrieved March 22, 2021, from https://www.canada.ca/en/services/environment/conservation/sustainability/circular-economy/world-forum-2021.html