

STANDARDS RESEARCH

The Circular Built Environment in Canada: A Strategic Framework for Future Action

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Foreword

This report was completed by Innovation North—an initiative of the Ivey Business School, Western University. This work is the second phase of a three-phase project to build a strategic framework for a circular built environment in Canada, an initiative co-led by Circular Economy Leadership Canada (CELC) and CSA Group. The first phase is summarized in a report completed by Helen Goodland and Kelly Walsh of SCIUS Advisory, "The circular built environment in Canada: A review of the current state, gaps and opportunities" [1]. An intended third phase will identify specific next steps toward a circular built environment (CBE), based on the strategic framework developed in this report.

Innovation North is a research-practice collaborative at the Ivey Business School that tackles complex business issues. It is guided by a methodology, which we call the Compass, that applies systems thinking to innovation. A systems approach recognizes that many business and societal problems are complex and present differently to many groups, introducing significant barriers to change. Therefore, changes to these systems require coordinated actions that can nudge the systems forward. As systems are dynamic in nature, this report is not a definitive guide to a CBE, but rather a reflection of the actions that can enable a built environment today.

The terms of reference for this report included building a strategic framework as a significant step toward developing an action plan. Our aim was not to specifically define who carries out what action, but to provide a set of actions that can mobilize a CBE. We generated our insights using three important information sources:

1. desktop research, including the report developed by SCIUS Advisory in Phase 1 of the project;

2. twenty-five one-hour interviews with 30 key informants; and

3. three virtual workshops and one in-person workshop, involving 60 people in total.

We also received detailed feedback from CSA Group throughout the process and the Project Advisory Panel on report drafts. Although we sought to include a broad range of voices, we recognize the many important omissions, including the voices of Indigenous peoples. These voices are important to ensure that we see all parts of the system and not just those seen by the most influential or mainstream actors.

We sincerely hope that if the same research is conducted three years from now, we would be able to write a different report because CBE would be further advanced.

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Executive Summary

The objective of this report is to develop a strategic framework for a circular built environment (CBE) in Canada that is ready to feed into a detailed strategic framework. We focus on buildings that typically exceed 600 square metres or three stories in height and exclude smaller buildings, such as single-family dwellings. Although a CBE can include any material, we focused particularly on wood, concrete, and steel for this report. We did not include material efficiency on-site or smaller renovations. Additionally, our focus was on material use and reuse, and therefore energy efficiency was beyond the scope of this report.

In this document, we outline how organizations can help mobilize a CBE through the adaptive reuse of existing buildings, the adaptive design of new buildings, and the reuse of materials. The circular economy is inherently a systems problem because it involves so many actors with interdependent activities. To enable a CBE, it is important to involve not only those actors that contribute directly to a built environment, such as owners, developers, and builders, but also those that can enable change, such as standards organizations, architects/engineers, and the government.

This report also outlines the first moves and second moves. The first moves will lift barriers, take small actions, and celebrate wins. Second moves will widen the circle to build upon those first actions and invite more actors. Overall, the following actions will greatly support the move toward a CBE:

1. Define CBE concepts using standards
2. Develop educational resources for central and direct actors (i.e., introductions to the concepts and benefits; how to ask for circularity in a request for proposal [RFP] for a developer's new project)
3. Build coalitions, starting with front-runner organizations and adding fast followers
4. Research how to build physical viability (e.g., options for disassemblable connections or the safe reuse of wood in structural applications) and financial viability (e.g., markets for reclaimed materials) and develop recommendations for viable solutions
5. Connect current municipal policy goals and projects with opportunities to incorporate circularity practices



"A circular built environment (CBE) involves three core elements: the adaptive reuse of existing buildings, the adaptive design of new buildings, and the reuse of materials."

1 Introduction

The construction industry contributes approximately $141 billion to the Canadian economy annually [2]. Shifting the Canadian construction industry from a linear take-make-waste economy to one that is circular would affect the Canadian economy, influence how Canadians live, and impact the natural environment.

A circular built environment (CBE) involves three core elements: the adaptive reuse of existing buildings, the adaptive design of new buildings, and the reuse of materials. These elements will help to future-proof the built environment, as they can adapt to changes in business and user needs; create more affordable, low-cost infrastructure when materials stay in use longer; and contribute to a more resilient and sustainable natural environment by keeping materials out of landfills and extracting fewer resources.

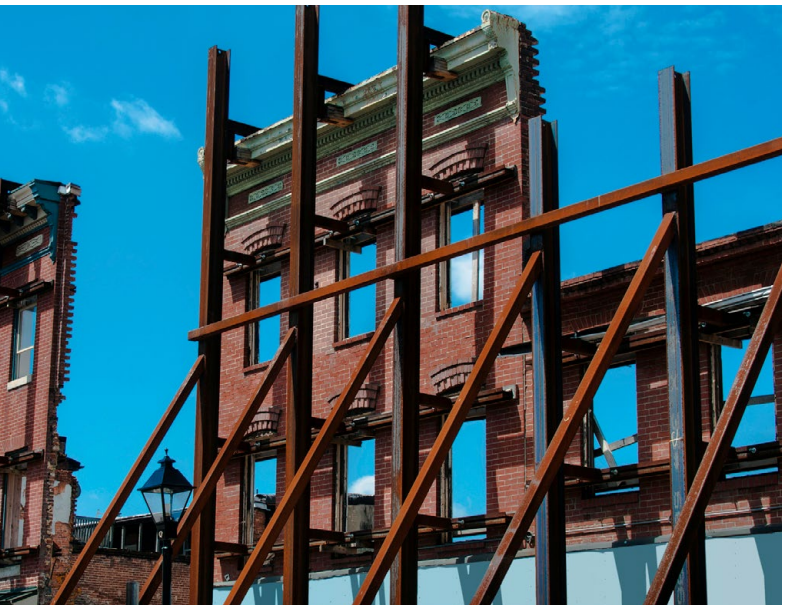
These benefits highlight many reasons for a CBE; however, it has been difficult to mobilize because the linear model upon which the built environment has evolved is deeply embedded in industry supply chains, construction techniques, and mindsets. The current approach to the built environment evolved at a time when natural resources were cheap, landfill space was plentiful, and stressors on the natural environment were almost invisible. As such, changing general business practices to create a CBE is extremely challenging.

To shift the construction industry, one needs to appreciate the range of actors involved in the system. The most central of these actors are owners and developers, who at times are the same and ultimately make building decisions. However, other actors also directly influence these systems, including architects and engineers, material/product manufacturers and suppliers, and deconstruction/material management companies.

Further, various actors can enable change for these direct actors, such as planners, investors, governments, standards development organizations (SDOs), non-government organizations (NGOs), and insurance companies. It is important for each of these actors to recognize their role in the system and the possible benefits they might offer and gain as part of a CBE.

Motivating change in the construction industry goes beyond giving people reasons to change. They need to see tangible opportunities and benefits, particularly due to significant risks and costs associated with building projects.

Re-evaluating the system requires stepwise, iterative change, which can be characterized by three key stages throughout this report. In the first stage, actors seek to reduce the barriers to change. In the second stage, owners/developers and architects design and build pilot projects. In the third stage, these pilot



projects (often called small wins) are celebrated and communicated widely. These stages are repeated, building on the previous stages and widening the circle of actors involved. Overall, this process will ensure that the CBE builds incrementally on past successes, ultimately leading to the emergence of a CBE.

Figure 3 illustrates our theory of change. At the beginning, front-runners work to lift barriers and establish the preconditions (Phase I) for circular building projects (Phase II), followed by celebrating wins and communicating learnings from CBE projects (Phase III). This process is then repeated, widening the circle to include fast followers the second time around, ultimately moving toward widening the circle to include mainstream actors.

Beyond offering a strategic framework, this project identified an important insight: the circularity movement is being driven by a small group of highly motivated and knowledgeable actors. Although there are many actors in the construction industry who care about elements of the CBE, they are not part of the immediate CBE community because they do not know, understand, or use the term "circularity" in their day-to-day work. We recommend a more meaningful term be used to describe circular elements in construction—one that resonates with a wider circle of industry actors, such as "future-proofing," which is already used in industry discussions that reference adaptable buildings.

This report expands upon the first phase of this project developed by SCIUS Advisory [1] using additional desktop research; 25 interviews with 30 key informants of the built environment in Canada; three virtual workshops that centred on wood, concrete, and steel; and an in-person workshop with industry leaders.

In the next sections, we describe how to mobilize a CBE. We deploy a systems design methodology, which we call the Compass, described in detail in Section 9. We start with describing the destination or North Star, followed by describing the Problem, building Awareness through a systems map, describing the Ideas that can address the Problem, and finally, enumerating Actions that will mobilize a CBE.

2 The North Star

At Innovation North, we use the North Star to describe the overarching goal and purpose of an initiative. It points to a desirable future, giving the innovation agenda both a destination (where and why) and a direction (how). Based on our conversations with industry members, our North Star guiding the CBE can be described as follows:

> *Imagine . . . if all developers and owners built commercial, large residential, and institutional buildings that used materials from regenerative sources, produced resilient buildings, avoided waste (including carbon throughout the value chain) and redirected all unavoidable waste back into the value chain.*

The actions outlined in this report aim to move us toward this North Star to bring about lasting systems change.

2.1 Defining a Circular Built Environment

Circular Economy Leadership Canada's (CELC) vision for a circular economy is an economic system that "advances a net-zero, nature-positive Canada, supporting economic prosperity through innovation and the well-being of Canadians today and for future generations" [3], [4]. A CBE seeks to redress the excess resource extraction and waste created by a linear industrial economy in which buildings are constructed, renovated, restored, or removed. In a CBE, materials come from regenerative sources (i.e., sources that continue to produce, such as wood) when possible, are kept in use longer in their highest-value possible use, and returned to the economy once they are no longer needed in their current form. A CBE affects every stage of the building life cycle — from design, to construction, to use, to deconstruction.

2.2 The Elements of a Circular Built Environment

After reviewing much of the prior research in this space, we identified three elements critical for a CBE: adaptive reuse of existing buildings, adaptive design of new buildings, and material reuse. In this section, we describe these outcomes and the relationships among them.

2.2.1 Adaptive Reuse of Existing Buildings

To achieve national environmental and carbon emissions goals, a priority activity for the built environment is the reuse of existing buildings [4], [5]. As community needs change over time, the types of buildings needed within a community often change, too. Reusing existing buildings allows for opportunities to transform them into something different from their original design and purpose, offering new life and functionality. An example of this adaptive reuse of buildings is converting a vacant office space into multi-residential units. This practice ultimately extends buildings' overall lifespan, preserving the embodied carbon [1] within, avoiding carbon emissions associated with new builds, and may even bring additional socio-cultural benefits to a community by preserving its heritage. Adaptive reuse projects were identified by our interview and workshop informants as one of the critical avenues for advancing sustainability in the built environment. Since most of the 2050 built environment has already been built, adaptive reuse will be a central strategy going forward [6].

Adaptive design concept definitions

Adaptability — a characteristic of a product's design that enables the product to be modified, relocated, or adapted during its useful life to accommodate a new or adapted use.

Disassembly — a characteristic of a product's design that enables the product to be taken apart at the end of its useful life in a way that allows components and parts to be reused, recycled, recovered for energy, or used for other environmental purposes [7].

Note: This characteristic can be applied to a product, system, component, or assembly.

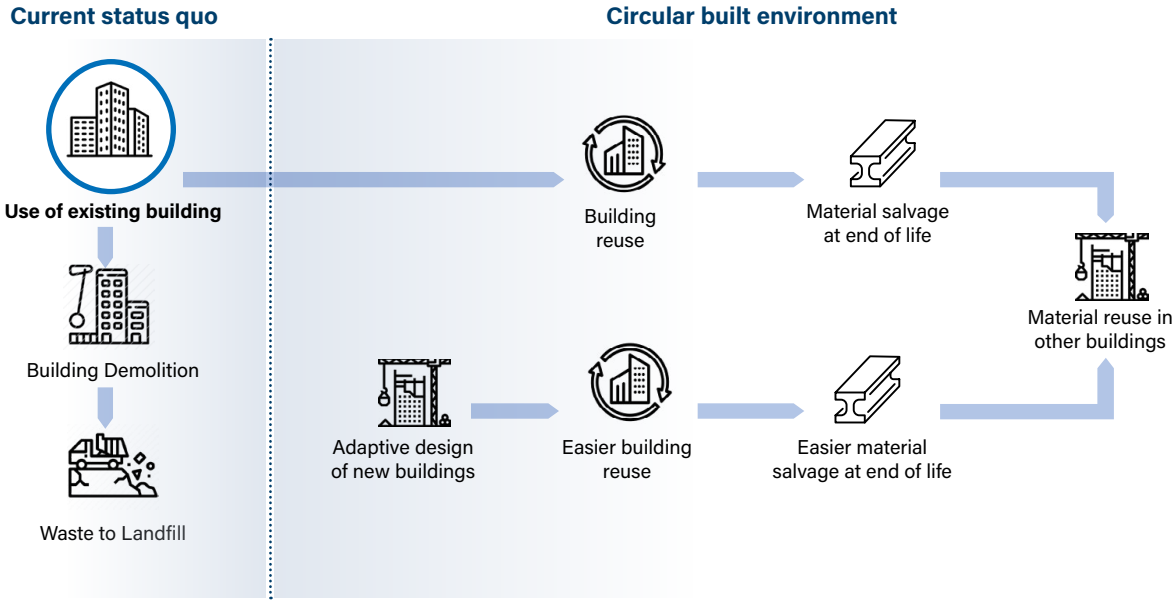
Disassembly/adaptability — a characteristic that merges the concepts of design for disassembly and design for adaptability in a way that enables a product to be adaptable for modification during its useful life with the components and parts [8].

2.2.2 Adaptive Design of New Buildings

Adaptive design is an umbrella term that describes various design strategies that permit buildings to be reconfigured during the building's use life and for material recovery at the end of the use life. These strategies include design for disassembly, design for adaptability, and design for deconstruction.

Adaptive design anticipates and facilitates opportunities to change the building's physical infrastructure, use, or purpose in the future, acknowledging that the needs of a built environment change over time.

Figure 1: The three key elements of a CBE. Graphics from Flaticon: DinosoftLabs (office building), Smashicons (demolition), Uniconlabs (landfill, steel), Pause08 (hook), and Freepik (construction)



2.2.3 Material Reuse

Whereas reusing existing buildings and designing adaptive structures tend to focus on the infrastructure, material reuse ensures that component materials continue circulating long after they are removed from buildings. The reuse of structural materials, such as wood, concrete, and steel, in building applications is particularly impactful in reducing the embodied carbon of the built environment. This approach is the most challenging to address because building design often stipulates the type, quality, and standards of materials used. Additionally, many materials, especially when reused, must undergo rigorous testing to comply with relevant applicable standards and codes (e.g., CSA 086:19 [9] and NLGA [10] grading currently allow for the remanufacturing, regrading, and reuse of wood in very limited applications; CSA A23.1:19 [11] currently allows for recycled concrete aggregate for low-strength applications). In many instances, insufficient data are available about specific materials and standards that help to mitigate risks. Consequently, our informants reported that while adaptive reuse and adaptive design strategies could be implemented at the project level now, material reuse needs more preparatory work to be widely implemented.

2.2.4 Relationships Among the Three Elements of a Circular Built Environment

Figure 1 illustrates the relationships among the three elements of a CBE and how they reinforce one another and disrupt the typical progression of demolishing existing buildings and landfilling their materials. A CBE paradigm would transition salvaged materials at the end of their life cycle.

Simultaneously, new builds in the CBE paradigm use adaptive design strategies to simplify adaptive reuse and disassembly for material recovery. Design for adaptability makes it easier to repurpose and reuse buildings in the future, as the physical structures can be more easily updated. Similarly, designing for disassembly and deconstruction would help enable the salvaging of building materials for reuse since these design strategies allow materials to be removed intact (instead of conventional demolition). Salvaged materials that are recovered from existing and future buildings can be used for future building projects—ideally, ones that continue utilizing adaptive design or building reuse principles.

3 Problems Addressed by a Circular Built Environment

Circularity is often met with resistance due to the complexity of its implementation, therefore it is important to outline the benefits for moving to a CBE. In this section, we highlight the benefits of circularity specific to industry actors, including future-proofing, affordability, and ecological sustainability. Ultimately, circularity is a catalyst for benefits that can be enjoyed by individual industry actors across the entire system.

In this section, we outline the benefits that will be pertinent to a wide range of actors, focusing primarily on owners and developers who are critical to developing a CBE.

3.1 Future-Proofing Buildings

Circular strategies can mitigate market volatility in the built environment by future-proofing buildings. New circular buildings are built with adaptation in mind, so they can be transformed for multiple uses as the needs of users change, such as the shift away from office work triggered by COVID-19. Circularity also invites innovative design that prioritizes longevity, rendering buildings more durable and resilient.

3.2 Future-Proofing Construction

Not only will buildings be better equipped to withstand volatility, but so will the entire construction process. The Canadian government's climate target of net-zero emissions by 2050 will shape public policies around construction, such as those around embodied carbon in the built environment [12]. Corporations are following suit by committing to net-zero targets and seeking to occupy lower-impact buildings [13]. Finally, circular strategies encourage the use of sustainable materials that bolster resilience to supply chain disruptions from economic volatility, climate change, and material shortages. At its current state of skill and supply, the reused materials market is subject to similar supply chain and labour volatilities as new materials. It is anticipated that as the reused materials market matures, the volatility will decrease beyond that of the new materials market since there will be significantly less reliance on virgin natural resources.



Saskatchewan

Big Block Construction used modular construction to build affordable housing for Silver Sage Housing Corporation's Home Fire complex [14].

3.3 Lower Cost, More Affordable Buildings

Circular housing can significantly lower costs for builders and increase the availability of affordable housing by focusing on modular, deconstructable buildings. Modular buildings can be cheaper than on-site-constructed buildings, construction times are shorter, design elements are standardized and repeatable, less material waste is produced, and the buildings are generally more flexible [15]. Also, home relocation, which is outside the scope of this report, can increase affordable housing access through reused assets, especially in rural areas [16].

3.4 Ecological Sustainability

Globally, the construction industry consumes more raw materials than any other sector and accounts for an estimated 25 to 40% of the world's carbon emissions. In Canada alone, this sector generates 4 million tonnes of waste per year [17], which disposes of product that has economic value and eliminates the productive use of land that must be dedicated to waste storage. Further, stripping the land of natural resources reduces biodiversity and contributes to carbon emissions during activities, such as extraction and production, called *embodied carbon*. As use-phase *operational carbon* emissions are lowered due to improved energy efficiency, embodied carbon is becoming a larger share of the built environment's emissions.



4 The Barriers to Advancing a Circular Built Environment

For all these benefits, the obvious question is why isn't the built environment more circular? There are several barriers to circularity, including those described below.

4.1 Lack of Awareness About Circularity and its Implications

Circularity is not widely known among many industry actors in the built environment. Industry actors may also assume that circularity will add cost and time to a project. Whereas this might be true in some cases, a growing number of buildings constructed with circular design principles are cost effective, well-designed, adaptable, and resilient.

4.2 Design of Existing Buildings

Several barriers to adaptive reuse can arise. Many structural drawings are lost, incomplete, or outdated. Even if the old drawings are available, it is likely that the building has gone through several smaller renovations over its life, altering the structure from the original drawings. This means many costs arise for inspections and to verify the existing structure and its current structural properties, leading to many unknown costs that may come up during the project (e.g., expensive foundation rework). A loss of structural efficiency can also occur, as the structure was designed for a different layout/purpose of building; expensive foundation rework; and obstacles from key features that cannot change, such as ceiling heights.

Older buildings are often not suited for repurposing and their materials may not be conducive to reuse. For example, high-rise commercial buildings lack sufficient exterior windows relative to their floor space, making it impractical to convert commercial spaces to residential. Some features may be unchangeable, such as ceiling heights. Sometimes, older buildings fail to meet modern safety standards, such as material strength or accessibility, or they may contain asbestos or mould that is expensive to safely remove. Similarly, adapting an existing building for a new purpose may pose challenges to integrating appropriate modern technology and prioritizing inclusive design. Land use and zoning laws can also prohibit the repurposing of old buildings for new uses.

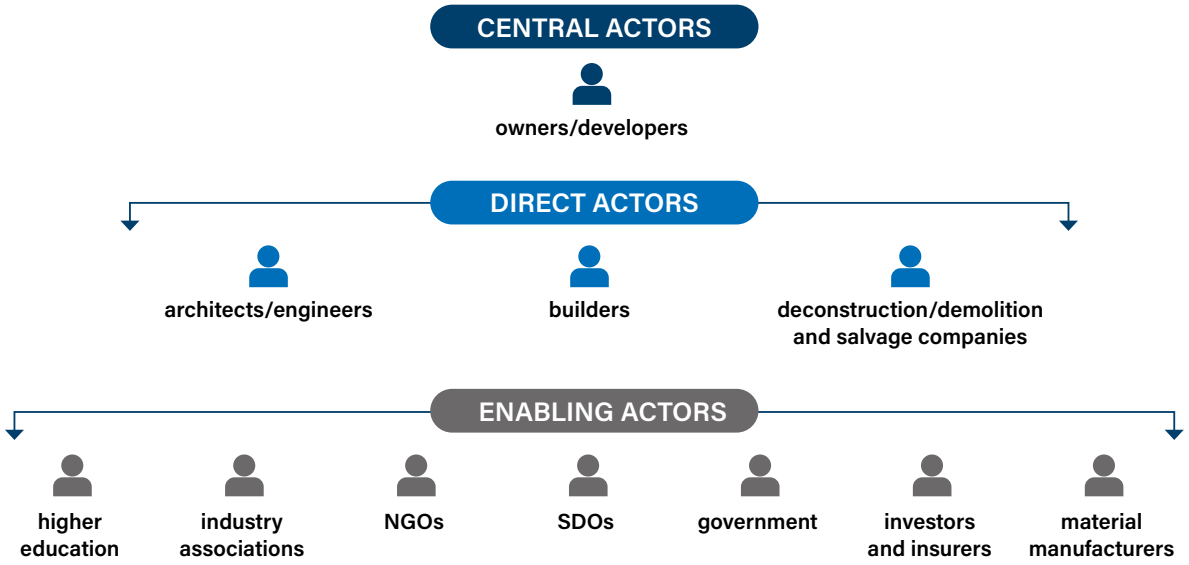
4.3 Construction Products and Techniques that Hamper Reuse

Contemporary "efficient" building techniques include the use of adhesives that hamper disassembly, adaptation, or deconstruction. Material manufacturers find it cheaper and faster to use adhesives, especially given the current low demand for reusing materials. Additionally, according to our interview and workshop participants, the construction industry deems it faster and cheaper to mechanically demolish a building rather than deconstruct the building and preserve its materials.

4.4 Lack of Knowledge and Certification for Material Reuse

There are existing knowledge gaps regarding the safe reuse of building materials in building applications. For this reason, engineering design codes, such as CSA 086:19 [9], generally do not allow for second-hand materials to be used in structural applications, as the wood industry does not currently have a process to grade used structural lumber for future structural applications.

Figure 2: Main actors for mobilizing a CBE



4.5 Relative Pricing of New Versus Reclaimed Construction Materials

The price of reclaimed materials and the labour required to extract them is higher than for new materials, because there is a shortage of supply for an already limited demand. Transportation and storage challenges exacerbate the costs and inconvenience of using reclaimed materials. Further, big box stores offer a "one-stop" shop to builders for new materials, whereas no reliable secondary markets exist for reclaimed materials. Vendors must visit multiple platforms and locations for limited (sometimes degraded) supplies, which only adds time and labour costs.

4.6 A Culture of Always Building New

Industry actors informed us that there is a strong bias among their peers and consumers for building new, rather than renewing old structures. In Canada, few twentieth century buildings were built with reuse in mind, so the quality of construction and materials used can be relatively poor. Additionally, architects and engineers often want to be recognized for their new, trendy, and original designs; urban centres are often focused on new construction projects; and tenants tend to prefer living in fresh, new buildings. Newer is often equated with better. The current fee structure further incentivizes new construction, as adaptive reuse and adaptive design require more upfront planning that can increase costs, which are difficult to include in a competitive tendering environment.

5 Actors that Can Advance the Circular Built Environment

Since this research takes a distinctly *systems-focused* approach, many actors play an important role in a CBE. No single actor can advance the CBE alone. It can only happen through the collaboration and cooperation among actors who assume different roles within the system.

Consequently, actors within a system exhibit differing levels of influence, involvement, and specialization. We identified three overarching tiers of actors: a **central actor** who has the most influence in a CBE, **direct actors** who play a supporting role, and **enabling actors** who can lift critical barriers to enable change. Actors can play different roles at different times, but our organizing framework recognizes the importance of their respective roles in actualizing a CBE.



"By reusing existing spaces, owners/developers are often able to access prime downtown locations, preserve historic and cultural heritage, and may even be eligible for related municipal incentives."

Figure 2 illustrates the key actors in a CBE, starting with the central actors that make key project decisions, direct actors involved in building projects, and enabling actors that lift barriers and establish the preconditions for action.

5.1 Central Actors

In our framework, the central actors are responsible for identifying the project, determining the scope of the project, deciding which actors/companies they will involve in the design and building process, outlining the budget, and ultimately, funding the project.

5.1.1 Owners/Developers

In the built environment, the primary central actor is the owner/developer. Although owners are more inclined toward long-term impacts and developers may generally be focused on short-term gains from building sales, we grouped them together because owners and developers may be the same or the lines between these groups can be blurred. Owners/developers with long-term stakes may be more inclined to pursue circularity. Also, owners/developers set the conditions of satisfaction, which delineates the goals and values most important to the project.

Role in activating the circular built environment

As the primary decision makers that oversee and approve project plans, owners/developers play a key role in advancing circularity. If they choose to reuse an existing building, to design adaptively, or to utilize second-hand materials, they can influence direct actors in the system (i.e., architects, engineers, builders) to execute these plans.

Benefits to the actor

Owners/developers can receive several benefits from incorporating circularity into their business plans. First, circularity contributes to future-proofing assets, making them adaptive to future market shifts and helping retain asset values. For owners, this future-proofing practice increases the likelihood of preserving the value of a given asset. For developers, this adaptivity may make the building more attractive on the market for owners looking for future-proof assets that can adapt with the times. By reusing existing spaces, owners/developers are often able to access prime downtown locations, preserve historic and cultural heritage, and may even be eligible for related municipal incentives [31]. Additionally, circularity can reduce a building's lifetime embodied carbon by prolonging materials' use lives. Life cycle carbon requirements for buildings are expected in the 2030s, which aligns with the federal government's objective to support the development of new language for the 2030 National Model Codes that will enable the regulation of embodied greenhouse gas emissions [18]. This would increase the benefits of employing circular design and building methods, thereby increasing the benefits of employing circular

design and building methods. Moreover, circularity can help mitigate the risk of ending up with "stranded assets" that lose economic value (or even become liabilities rather than assets) as regulations and markets change, which is of increasing concern in the real estate sector.

5.2 Direct Actors

Direct actors work primarily within the construction industry. They include engineers, architects, and builders. These actors have the industry experience and technical knowledge to influence design and building concepts and techniques.

5.2.1 Architects/Engineers

Role in activating the circular built environment

Architects and engineers play a critical role in activating the CBE, as most decisions are made within the project's design stage. The actors that draw up the plans and define the technical specifications have a strong influence with mobilizing more circular ideas. Architects and engineers can advocate for adaptive design or the creative reuse of second-hand materials, particularly in projects that offer architects ample space for creativity, as opposed to those with very prescriptive, predefined specifications.

To encourage circularity, architects and engineers need to demonstrate the benefits to developers (i.e., increasing sales potential) and owners (i.e., future-proofing the asset). If the owner/developer client does not want a fully adaptable design, the architect can identify cost-effective design and material elements that facilitate future adaptation, such as minimal necessary overdesign for accommodating higher future loads or adding footings under the floors for potential future walls.

Since the various relationships that develop between owners/developers and architects/engineers greatly impact the projects they work on, architects/engineers can leverage this opportunity to advise their clients (i.e., the owners/developers) on integrating circularity practices and bring forward new concepts and ideas, rather than exclusively relying on their client to identify these opportunities.



Quebec

RÉCO market in Montreal collects and sells reclaimed building materials [19].

Benefits to the actor

For sustainability-minded architects and engineers, increasing opportunities for adaptive design will allow them to live their values in their work and influence change in the wider industry. Reusing existing buildings, designing adaptively, and determining how to use salvaged materials all present opportunities for architects and engineers to exercise creativity and innovation through unique, one-of-a-kind designs. Additionally, as life cycle reporting becomes increasingly common in Canadian jurisdictions and companies' environmental, social and governance (ESG) requirements, architecture and engineering firms that establish themselves as experts in circular design may have a competitive advantage.

5.2.2 Deconstruction and Salvage Companies

Role in activating the circular built environment

Deconstruction and salvage companies play an important role in facilitating material reuse. They can carefully deconstruct buildings while keeping materials intact (instead of using conventional demolition techniques), separate and warehouse the materials, and sell the materials for future use. Demolition companies and their recycling partners work closely to find recycling pathways for building materials.

Benefits to the actor

A CBE is ideal for the sustained financial success of demolition and salvage companies. For demolition companies, incentives to find the highest and best uses for discarded building materials will generate demand for their services, which are more expensive

than conventional demolition. Deconstruction companies may face future competition from conventional demolition companies that begin offering deconstruction services. This occurred in Metro Vancouver communities following the introduction of construction waste diversion bylaws.

In the nearer term, it may be easier for salvage companies to access reclaimed materials than to sell them for reuse. This is currently the case for one organization we interviewed that collects and sells used construction materials. A CBE will naturally drive up the inbound flow of materials, especially if there are incentives for diverting waste away from landfills. To increase the demand for reclaimed materials, incentives for using reclaimed materials in future buildings may be needed.

5.3 Enabling Actors

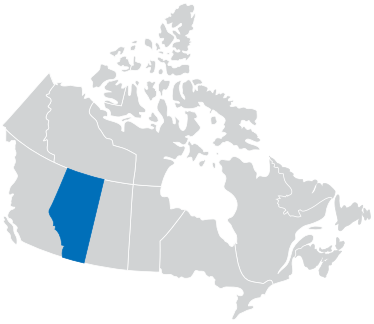
Enabling actors are those with roles that mobilize resources and tools that can lift some of the barriers or accelerate the transition to CBE. Actors in this group include (but are not limited to): manufacturers, investors, all levels of government and especially municipalities, SDOs, NGOs, educational institutions, industry associations, other research bodies (e.g., think tanks), and consultants.

5.3.1 Material Manufacturers

Role in activating the circular built environment

Material manufacturers play a critical role in activating adaptive design and, eventually, material reuse. The way in which parts of a building are connected determines whether they can be disassembled, and therefore material manufacturers need to offer disassemblable connector systems to unlock adaptive design. They can work with SDOs to ensure that disassemblable systems meet safety standards and will be accepted by provincial building codes.

Similarly, advancements in technology can be explored for materials that are more suited for reuse. For example, steel is, as a material, generally easier to inspect to determine its structural condition.



Alberta

The City of Calgary offered incentives to convert 17 downtown commercial buildings into residential ones [20].

Therefore, in the current market state, it is more easily reused than concrete. There is also an opportunity for advancements in simplifying or improving the process to reclaim materials.

Benefits to the actor

The CBE will create a market for disassemblable connection systems. However, it is likely that material manufacturers will need incentives and certification support to bring disassemblable systems to market. Material manufacturers could benefit by offering disassemblable connections as products as a service or through other innovative leasing schemes, where manufacturers retain ownership of the product and can "sell" it multiple times.

5.3.2 Investors

Role in activating the circular built environment

Investors provide and protect resources that finance the CBE. Investors can play an important role in removing financial barriers by offering more favourable terms for circular projects. Adaptive buildings, in particular, may be more likely to retain their value amid future market changes. For example, the Canada Mortgage and Housing Corporation could add circularity criteria to its mortgage loan insurance funding program, MLI Select, funding program, which currently offers more favourable mortgage insurance rates based on a project's level of affordability, energy efficiency, and/or accessibility.



“Governmental bodies at all levels play a significant role in activating and advancing the CBE.”

Benefits to the actor

Adopting favourable terms for circular building projects can align with investment firms’ ESG requirements for their investments. Investors may also attract more borrowers who are interested in prioritizing green construction projects over others.

5.3.3 Governments

Role in activating the circular built environment

Governmental bodies at all levels play a significant role in activating and advancing the CBE. For example, at the national level, the National Building Code of Canada may provide technical solutions by developing a national retrofit code and referencing relevant standards on reuse of existing buildings and materials, as well as adaptive design. Regulatory bodies at national and provincial levels have significant regulatory and financial powers in the transition to CBE. For example, they can activate the transition by offering grants for research and technology transfers, improving procurement policies which favour reuse and waste diversion, and providing financial incentives which incentivize market uptake.

The role of municipalities is also particularly worth highlighting. Municipalities have the most influence when it comes to reusing existing buildings and materials, but they still have a role to play in adaptive design. They issue permits, conduct inspections, and hold zoning bylaws. Municipalities have jurisdiction over dictating what is possible for advancing the CBE from a legislative and logistical standpoint.

For example, municipalities could waive development fees for and/or subsidize adaptive reuse projects. They could also relax requirements, such as those for parking, overshadowing, and service upgrades. It may be advantageous to position these as affordable housing and/or downtown revitalization initiatives. Further, municipalities can set zoning bylaws that more easily allow for existing building reuse (i.e., switching from commercial to residential). Changing zoning specifications may also make adaptive design more appealing. Additionally, municipalities can play important roles in knowledge sharing and convening those with interest in this space. For example, in the City of Richmond, British Columbia, organizations contribute ideas, strategy, and pilot projects to help advance the city’s circular built environment goals.

Benefits to the actor

Municipalities that support the CBE will contribute to their regional environmental targets. By keeping buildings in use longer, the municipality can build more affordable and flexible housing for residents. They can also reduce the safety risks and potential tax revenue losses that come from empty lots by keeping buildings from being torn down. Additionally, circular strategies can reduce construction waste, which takes up a great deal of space in landfills and contributes to municipal government costs. Municipalities may also build a positive reputation for innovation and forward-thinking practices. This perception may attract new residents and businesses to the region, thereby driving social and economic development.

5.3.4 Standards Development Organizations

Role in activating the circular built environment

SDOs can help de-risk transitions to circularity by setting technical standards that will maximize the safety of adaptable buildings and those that use reclaimed materials. For example, there is a CSA standard for adaptive design, CSA Z782-06, *Guideline for Design for Disassembly and Adaptability in Buildings*, which provides a framework for various actors to reduce waste generated by building construction materials [8]. More can be done to increase the uptake of technical standards that support circularity practices. For instance, SDOs can further disseminate and educate industry members on the use and implementation of standards for circularity. This may include offering boilerplate language for owners to use for adaptive design in requests for proposals or working with material manufacturers to ensure that disassemblable connection systems are up to code. SDOs can also work with research, material, and certification partners to develop new standards on the safe reuse of building materials, which is especially critical for reuse in both structural and non-structural applications. Currently, codes do not allow the use of reused materials for structural applications, and they are generally silent on their use for non-structural ones.

Benefits to the actor

Mobilizing existing circular standards can create new revenue opportunities by increasing the sales of standards documents. More broadly, it facilitates SDO objectives to develop technical standards that improve health, safety, and the environment.

5.3.5 Industry Associations

Role in activating the circular built environment

Industry associations play an important role in raising awareness about circularity and communicating successful developments. Industry associations can reach many industry actors and can translate adaptive design principles to align with industry's acute concerns (e.g., performing on time and on budget). Industry associations disseminate knowledge, influence regulations, and provide fuel for innovation among their member actors. Further, industry associations can encourage members to reuse existing buildings or materials, or both, as well as point them toward key resources for moving forward. Industry associations could also showcase successful pilot projects to architects, engineers, developers, and owners. Industry associations can also collaborate with other industry actors to launch a design challenge to further motivate their members to integrate circular practices into their work. Industry associations can connect direct actors with other enabling groups and can leverage their existing influence among their members, who already turn to them for guidance, information, and advice.

Benefits to the actor

Industry associations in the Canadian built environment space currently educate their members on sustainability and motivate sustainable choices. Existing sustainability programs offered by industry associations generally focus on energy efficiency rather than circularity. Expanding their sustainability education efforts to include adaptive design and building reuse can help industry associations educate and activate the most forward-thinking of their members to provide a valued service. It also ensures that they remain competitive in their sustainability efforts alongside other industry associations.

5.3.6 Circular Built Environment Non-governmental Organizations

Role in activating the circular built environment

NGOs are important players in facilitating a CBE. NGOs can support circular practices by convening and educating different industry actors, acting as a critical bridge between potential future collaborators. They can develop educational materials to share with other partners (e.g., industry associations); connect people to promote knowledge sharing and new partnerships; and research, write, and disseminate successful case studies. NGOs can explore opportunities for collaboration (e.g., with industry associations), discuss opportunities for scaling up circular building design programs in higher education (e.g., the Applied Circular Economy microcredential offered by British Columbia Institute of Technology [BCIT]), match investors with

CBE businesses, and develop knowledge sharing resources and avenues to be used by those working directly in the built environment industry.

Benefits to the actor

NGOs who contribute to the circular economy space can advance their mission by engaging directly with the construction sector given its prominence in the Canadian economy and its high-impact potential to become more circular. Given that the full benefits of adaptive design may not manifest for a few decades (i.e., when today's new buildings would typically be demolished), mobilizing efforts around adaptive design is crucial in helping CBE NGOs to reach targets for future circularity of the built environment.

5.3.7 Higher Education and Research Institutions

Role in activating the circular built environment

Higher education and research institutions directly influence the next generation of actors working within the built environment. Their role in promoting circular practices includes educating emerging architects and engineers on how to execute adaptive design. By teaching circularity concepts to students, new architects and engineers will join the workforce better equipped with the knowledge and tools to consider adaptive reuse, adaptive design, and material reuse options. Updating curricula can be slow, however, existing CBE training programs can further develop and serve as a template for other institutions to adopt, such as the BCIT's Applied Circular Economy microcredential. Additionally, professional associations can facilitate these efforts by advocating for the inclusion of specific skills in more traditional architecture and engineering programs, leveraging the growing momentum behind life cycle assessments and embodied carbon reporting requirements.

Benefits to the actor

Higher education programs benefit from teaching circular design and execution skills because this positions them as sustainability forerunners and promotes innovation in their trainees. Firms may move toward greener or more circular processes, or both, in the coming years, and therefore will be looking for graduates who are well versed in these concepts. Expanding curricula to include circularity will ensure that higher education institutions remain competitive when recruiting prospective students.

6 A Strategic Framework

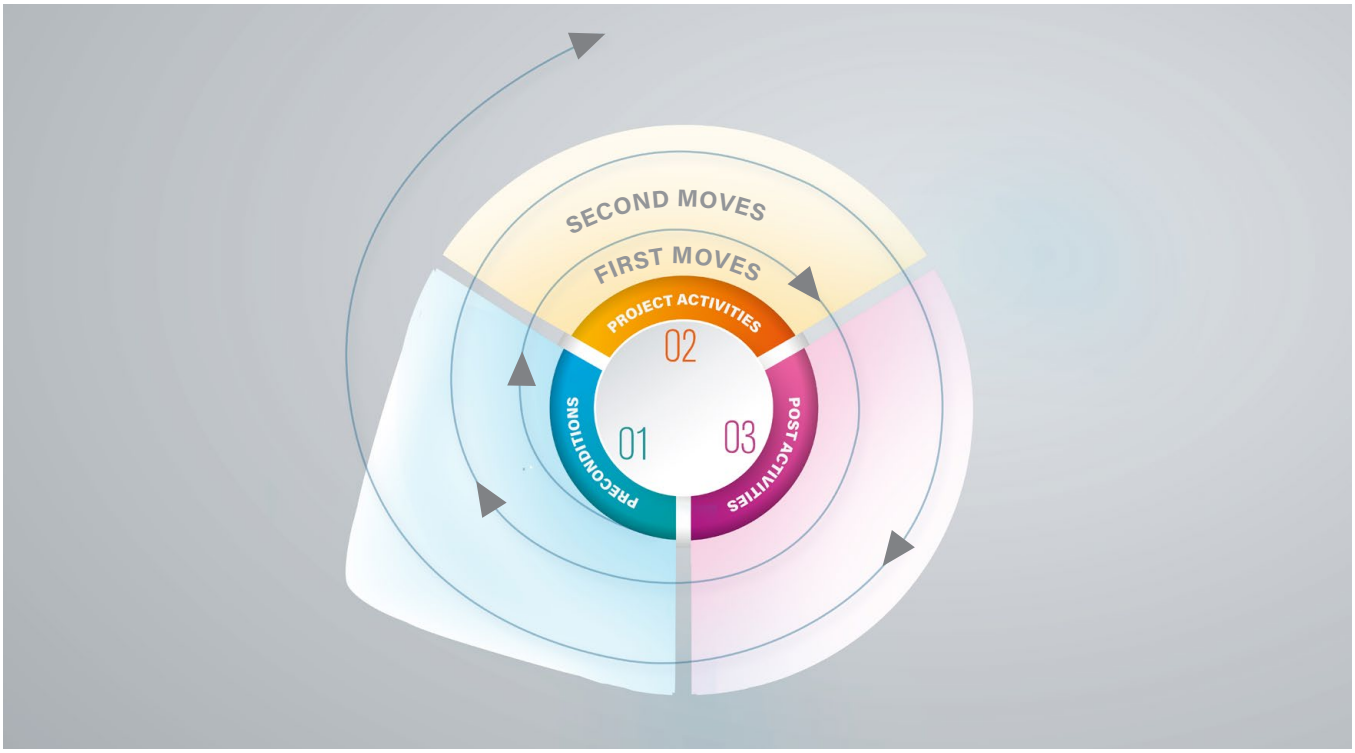
In this section, we present a strategic framework that details actions needed to mobilize various industry actors (Section 5) to implement the elements of a CBE (Section 2.2). We focus primarily on short-term actions (those possible within one to three years), because the downstream impacts of early actions on complex systems can be difficult to predict. Some actions can catalyze significant changes, whereas others lead to limited change. Each action and its subsequent effects reveal increasingly more about the overall system; therefore, it is important to nudge the system forward, re-evaluate the landscape, and then reprioritize subsequent activities.

For these reasons, we categorize the actions into three stages. These stages are repeated quickly over time in first, second, and subsequent moves. The first moves involve front-runners, and subsequent moves involve fast followers and ultimately the broader community. This process of scaling up involves relatively small experiments and nudges that build on each other. The general process is illustrated in Figure 3, and details of the action plan are provided in subsequent subsections.

Figure 3 illustrates our theory of change. At the beginning, front-runners work to lift barriers and establish the preconditions (Stage I) for circular building projects (Stage II), followed by celebrating wins and communicating learnings from CBE projects (Stage III). This process is then repeated, widening the circle to include fast followers the second time around, ultimately moving toward widening the circle to include mainstream actors.

Stage I sets the preconditions for the CBE (Section 6.1). The primary objective of this stage is to remove barriers or frictions that have prevented a CBE's development.

Figure 3: The process for mobilizing systems change for a CBE



If these barriers or frictions are not addressed, then any force applied to mobilize a CBE will be resisted. These frictions can range from industry members' lack of familiarity with the CBE concept to CBE barriers in the national model building code, which is implemented with adaptations in provincial building codes.

It is noteworthy that *enabling actors* typically play a bigger role in this stage than direct actors. Enabling actors help to reduce barriers in the system, which then makes it easier for direct actors to create change. Enabling actors can update provincial and national building codes (such as by including adaptive design and material reuse), policies (such as municipal zoning laws to make adaptive reuse easier by allowing sites to change between commercial and residential uses) and provide incentives (such as municipal governments fast-tracking permits for circular building projects).

Further, enabling actors can convene coalitions of direct actors who are the front-runners, and this convening function can help direct actors to coordinate collective action. These front-runner direct actors, especially, are willing to experiment and invest in new, potentially unproven, solutions. These champions and early adopters can work with their organizations and industry associations to build awareness around the concept of circularity, why it is valuable, and how to implement it.

Stage II involves the project activities driven by the central and *direct actors* (Section 6.2). The primary objective in this stage is to mobilize the circular economy. Relatively few activities are driven by this group, primarily because only the direct actors are involved: owners/developers and architects/engineers, ideally in collaboration with each other.

Owners/developers can benefit from learning more about circular buildings and architects/engineers can refine the communication of CBE design qualities and proposed value to their clients. Additionally, architects and engineers will need to know how to design and create buildings to meet circularity standards. Material manufacturers contribute by providing connection systems that can be disassembled, and deconstruction and salvage companies can recover valuable materials at the end of a building's life for future use.

Stage III promotes successes by communicating and celebrating quick wins (Section 6.3). The purpose of this stage is to publicly endorse and exhibit the work to motivate more actors (i.e., fast followers) to replicate the circular building practices demonstrated by the front-runners. Fast followers, who tend to be a bit more risk averse than front-runners, will be willing to implement innovations shown to work.

A fast, iterative process will increase the visibility of feasible and successful CBE projects to allow future projects to build upon these successes and bring more fast followers on board.

In Section 7, we describe how actors can further mobilize these actions to ensure that the CBE elements described in Section 2.2 will emerge.

6.1 Preconditions: Removing Frictions

One of the biggest overarching challenges we have seen in the transition to circularity in the built environment is the lack of clarity on where or how to begin. This challenge has been described as a "chicken and egg problem" countless times in our interviews and desktop research. There appears to be a general sense among potential actors we spoke with that a great deal of coordinated change needs to occur. Due to the complexity and magnitude of coordinated action required among various actors to push the industry toward circularity, enabling actors can provide critical leadership by convening central actors, direct actors, and other enabling actors to work in parallel through strategic partnerships. In particular, provincial and federal governments and NGOs are well positioned to address these barriers and drive industry transformation.

By initiating a set of preconditions, we can establish an environment that facilitates circular building projects to break through that paralysis, as shown in Table 1. These precondition actions can be implemented primarily by enabling actors to reduce barriers that prevent owners/developers from choosing to launch circular building projects.

6.1.1 Building Awareness

First, owners/developers need to be aware of existing circular building principles and the benefits of their implementation, including clarity on what CBE entails. In the first moves to support building awareness, enabling actors will define concepts related to the CBE (e.g., through standards), develop educational materials, and begin the process of educating direct actors through channels like industry associations. At this stage, we recommend that an enabling actor (e.g., an NGO) takes the lead on developing a guide for how different actors can begin incorporating CBE practices into their work and how to manage new collaborative relationships for CBE projects. The second moves from this space will build on the first moves to educate direct actors on how to implement technical CBE standards and formalize educational pathways, such as through higher education institutions.

Centring the three CBE elements—adaptive reuse of existing buildings, adaptive design of new buildings, and material reuse—is likely to resonate more than emphasizing the general concept of circularity, as these elements are more specific and familiar. SDOs can play a key role in characterizing these CBE elements by developing standardized definitions and providing harmonized technical guidance. Likewise, the federal and provincial governments can begin incorporating CBE concepts into building codes as well as CBE-specific financial opportunities (e.g., grants) and procurement policies, whereas municipalities can develop CBE language in their permitting and zoning bylaw decisions. Additionally, emphasizing the future-proofing benefits of adaptive design is likely to resonate most with owners/developers, since it allows buildings to change as the market's needs change. Industry associations can be valuable conduits for introducing CBE principles to their members.

Table 1: Points of friction and proposed solutions

Proposed Solutions	Key Actions	Points of Friction Addressed by Actions
Building Awareness	▪ Building awareness around circular building principles (e.g., adaptive re-use of buildings, adaptive design, and material reuse) and their benefits	Actors lack capacity, understanding, and/or support systems to initiate change
Building Awareness	▪ Motivate architects and engineers to propose circular approaches to their clients	The entrenched mentality within the construction sector that "it's the way things have always been done"
Physical/Financial Viability	▪ Centralizing warehousing and reuse markets to ensure reusable materials are as easy to access as new materials	Difficulties in accessing reusable materials, especially within tight project timelines
Physical/Financial Viability	▪ 3D scanners and artificial intelligence tools can help determine what materials are in a building to identify their reuse options ▪ Enable architects and owners to maintain better records to facilitate easier reuse, adaptation, and material recovery	Lack of information on the circular potential of existing buildings
Physical/Financial Viability	▪ Prioritize high-leverage adaptive elements, such as footings for future interior walls, to allow for spatial reorganization and non-adhesive connection systems so that materials can be more easily reused	Fully adaptable design is expensive
Physical/Financial Viability	▪ Prioritize research on structural applications of reclaimed materials ▪ Develop standards and certifications for structural reuse of reclaimed materials	Lack of information on the structural applications of reclaimed materials
Building Coalitions	▪ Establish integrated design processes that allow different actors to work together from the onset of a project	Actors are overly siloed and operate within familiar contexts and with the same contractors, which limits exposure to new opportunities and emerging industry trends

Initial actions: Building awareness

First moves

- SDOs should develop and update their standards that define the three big ideas: adaptive reuse, adaptive design, building material reuse.
- NGOs should offer industry associations template educational materials that can be customized for their audiences.
- NGOs and industry associations should offer specific language to use in RFPs to ask for circularity.
- NGOs and industry associations should offer awareness-building education on the CBE concept and begin offering technical trainings.

Second moves

- SDOs should educate direct actors on how to implement technical CBE standards.
- Industry associations and higher education institutions should offer technical trainings and formalized education pathways.
- Federal, provincial, and territorial governments should:
  - Incorporate CBE criteria into the national building code, provincial building codes, and permitting and zoning decisions.
  - Improve procurement policies that favour reuse and waste diversion (see Phase 1 report [1] for further details).
  - Activate the transition to CBE practices by offering grants for research and technology transfers, and providing financial incentives to incentivize market uptake (see Phase 1 report [1] for further details).

The aesthetics of circular design should also be at the centre of CBE educational efforts. The attractive and creative nature of circular design is especially important for promoting circularity among architects, since many self-identify as artists. The aesthetic opportunities afforded by circularity can also be a strong motivator among owner/developer clients. The best of circular design should be showcased by all actors (e.g., NGOs, industry associations, industry media) to educate industry players about the various opportunities presented by circularity.

Once owners/developers are motivated to build a circular building, they need to find partners that know how to implement circular projects. Therefore, additional education on the technical details of implementation will support next steps. This is where industry associations and higher education institutions can have significant impact. Although many of the technical details are known in principle, best practices will emerge as circular projects are implemented more widely. These best practices can be distributed to owners/developers and architects/engineers through industry associations and media—as seminars and workshops, technical case studies, videos, and online resources and repositories—to generate a positive feedback loop between success stories and education.

6.1.2 Building Physical Viability

Next, actions are needed to pave the way to allow circularity to be physically viable. This relates to the physical materiality of buildings and the materials used

in their construction. The first moves in this space involve educating architects/engineers on the technical aspects of circular design, researching and developing disassemblable building connections, and researching future applications of salvaged building materials. The second moves focus on developing standards for these new connection systems and reused material applications so that they can be brought into practice.

In **adaptive reuse**, the biggest physical challenge is uncertainty around what exists behind walls and how buildings can be reused. Oftentimes, building information is lost with time. Although original blueprints may be accessible, details on subsequent renovations may be missing. Additional concerns, such as mould and asbestos, are often not easily visible, and owners/developers may be hesitant to take on a building project without a complete understanding of potential or unexpected issues. Luckily, 3D scanning and artificial intelligence tools can now model existing buildings and assess their structure and general condition, which can alleviate some of these uncertainties.

For **adaptive design** in new builds, builders and designers face challenges associated with the material used for the structure itself and the design of connecting elements that can be taken apart later. Oftentimes, modern buildings are held together with permanent adhesives, which are cheaper and faster to use than more mechanical means of connection, but these structures cannot be easily disassembled. Material manufacturers can play a big role in overcoming this physical barrier by innovating connection systems that can come apart and bringing them to market. From there, architects/engineers will need to learn how to incorporate these connection systems into future designs. This can also be done to address and design structures with materials that can more easily be inspected and reused for structural purposes. Moreover, a checklist of adaptive design elements could be developed by CBE NGOs to better enable adaptive design's uptake in practice.

The physical barriers to **material reuse** require more research**.** At the most fundamental level, gaps in knowledge remain about if and how structural building materials can safely be reused in structural applications as well as how to certify them for reuse. Builders also often lack information about a material's history (e.g., load bearing, ultraviolet light exposure, cyclic loading fatigue, corrosive environments), which can affect material safety and structural condition. For example, a wood beam that has borne a heavy load for many decades may not necessarily be appropriate to use for load bearing in a new building's structure due to its potentially compromised structural capacity. Developing and understanding methods to appropriately assess and demonstrate the safety of reused materials is a critical component of unlocking this pillar of the CBE. Additionally, deconstruction companies can work to begin building partnerships with reuse/recycling intermediaries to aid in the distribution of salvaged materials.

6.1.3 Building Financial Viability

When CBE projects are physically viable, the next hurdle is ensuring that they make financial sense. The first moves in this space are to explore opportunities for favourable financing instruments and development policies, and the second moves are to implement them.

With circular buildings, the financial benefits tend to accrue over the building's lifetime, and upfront costs are often higher than in conventional projects. **Adaptive reuse** of existing buildings can be more expensive than building new if they require radical reconfigurations, such as converting office buildings into housing. **Adaptive design** may be more expensive if downstream actors are brought in earlier (i.e., in an integrated design approach) or if disassemblable connectors take more time to install than adhesives. **Material reuse** is often more expensive than using new materials, in part due to their limited availability and the labour costs associated with deconstruction. Over the long term, however, there can be financial benefits, as assets can retain value through reuse and adaptation, and further financial value can be captured from reclaimed materials that may otherwise end up in landfills.

The challenge, then, is to drive a shift to life cycle costing and total cost of ownership methods. For instance, framing circularity as an opportunity to avoid eventual losses in the life cycle of various materials will also increase the uptake of circularity practices that support pro-environmental action [22].

Initial actions: Physical viability

First moves

- Industry associations can educate architects/engineers on digitized tools, such as 3D scanning and artificial intelligence tools, for analyzing existing buildings.
- Material manufacturers need to ensure that there is a demand for connection systems that can be disassembled before they invest in research and development.
- NGOs should develop checklists for adaptive design elements.
- NGOs can work as an interface between material manufacturers and owners/developers and architects/engineers to help make a market.
- SDOs and material researchers can prioritize research that studies how to safely use and certify reclaimed structural materials for structural applications.
- SDOs and material researchers should also study methods of monitoring and conveying the load history of materials, which impacts their future safety.

Second moves

- To replace adhesives, material manufacturers need to innovate, communicate, and distribute connection systems that can be disassembled.
- SDOs should specify how to certify material systems that can be disassembled.
- SDOs should publish standards and certification specifications for reclaimed structural materials.

One step toward financial viability is opening new funding pathways to make circular building projects more financially viable for owners/developers. NGOs can explore potential sources of funding, possibly joint funding, from investors and government agencies. The aim would not necessarily be to unlock vast amounts of funding, but just enough to bring attention to the opportunities and tip the balance in favour of circular projects. NGOs could make a case for funding circular projects for both the financial benefits looking at the whole-life cost (e.g., future-proofing future assets against loss of value using adaptive design) and the ESG benefits, which make such projects particularly attractive to investors and governments. NGOs could gather evidence from existing circular projects to quantify the benefits and serve as valuable examples of circular building practices in Canada.

Additionally, municipalities can reduce the financial barriers to **adaptive reuse** by waiving or deferring development fees (which fund sewage systems, roads, utilities, and so forth), fast-tracking development permits, reducing property tax over a ten-year period, or subsidizing adaptive reuse projects. Such concessions are likely best positioned as “affordable housing” or “downtown revitalization” initiatives, as the term “circularity” may not resonate with voters.

Finally, new insurance products can help make circular buildings more financially viable. NGOs can explore opportunities with insurance companies to offer preferred rates or lower premiums for **adaptive reuse** because buildings will remain vacant for less time during renovations than in a new build. The challenges in managing and protecting vacant buildings makes them particularly high risk for insurance companies.

Initial actions: Financial viability

First moves

- NGOs can explore potential sources of funding, possibly joint funding, from investors.
- NGOs can explore opportunities with insurance companies to offer preferred rates or lower premiums for adaptive reuse.
- NGOs explore how to report on historical performance of existing buildings to demonstrate lower risk profiles.
- NGOs, research institutions, and/or municipalities can help to identify opportunities to facilitate material reuse, such as space offered by municipalities to store such materials.

Second moves

- Government agencies should develop funding programs and policies.
- Municipalities can reduce the financial barriers to adaptive reuse by waiving or deferring development fees (which fund sewage systems, roads, utilities, and the like), fast tracking development permits or subsidizing adaptive reuse projects.

Putting them back into active use by adapting these buildings for new uses accrues benefits to both owners and insurance companies.

The reuse of materials and other circular practices may also be considered high risk, and they may even push for higher rates unless they are also provided with evidence and information that circular practices can be done in a structurally reliable and predictable manner. The structural reliability of structures built using reused materials may be strengthened by development and adherence to safety standards and material certification. Having projects implementing circular practices proceed in a predictable manner may be improved by developing accepted processes for implementing circular practices. Additionally, NGOs can take the lead on researching how to evaluate and report on the historical performance of renovated buildings to demonstrate the lower risk profile.

6.1.4 Building Coalitions

Finally, coalition building and collaborating are essential for influencing systems change. New networks need to be formed that permit sharing information and executing circular elements. The first moves in this space are to engage front-runners in an active coalition, and the second moves are to bring fast followers into the fold.

For example, CELC and CSA Group have been important players in building CBE coalitions through the ongoing work by their Strategic Advisory Committee (SAC). The members of these groups hold significant expertise in developing and implementing a CBE roadmap. These leading organizations continue to engage their networks and ask partners to invite other experts, so CBE extends beyond the front-runner organizations that are already engaged.

As we discuss in greater depth in Section 7.2, we have found industry actors outside of the current core CBE actors (e.g., mainstream developers and architects) interested in engaging on topics that would be considered CBE. Since they are not explicitly positioned as circular design or development firms, they are not obvious recruits for CBE coalitions. These actors can be key in demonstrating the value of CBE to mainstream industry players who

Initial actions: Building coalitions

- CELC and CSA Group continue their SAC coordination.
- SAC members actively build their own coalitions around specific areas of focus (as has already begun because of this work).
- Other NGOs can follow suit by developing new opportunities for collaboration between key actors.
- CELC and CSA Group should convene both the CBE front-runners and these fast followers in synchronous workshops to continually iterate to identify the language and collaboration opportunities that will mobilize change.
- CELC, CSA Group, other CBE NGOs, and industry associations act as matchmakers to make direct connections between organizations.

might relate more closely to peer firms with similar mandates and organizational purposes than to firms focused specifically on circular buildings. We suggest convening both the CBE front-runners and these fast followers in synchronous workshops to continually iterate to identify the language and collaboration opportunities that will mobilize change.

CBE NGOs and industry associations can also act as matchmakers, directly connecting organizations to support their activities. For example, CBE NGOs can match investors with emerging CBE businesses to help them scale, and industry associations can engage with educators on the skill development needs for CBE implementation. For **material reuse** specifically, we have identified a need for CBE NGOs to incubate reuse and deconstruction actors to scale their operations and demonstrate their business case.

6.2 Project Activities: Moving Forward

The project stage involves the technical aspects of creating a circular building. This phase is centred on the relationship between owners/developers, architects, and engineers. These are key relationships, as they are where most of the big decisions are made. If circularity is not considered upfront in planning the project phase, it will likely not work its way into the plans later in the building cycle.

First moves

The first moves in this stage will be done by front-runner firms that already have an interest in CBE.

Circularity in building projects starts right from the proposal phase. If owners/developers already know they want to develop a circular design, they can submit it in their requests for proposals. They can build on boilerplate language developed by the enabling actors in the precondition phase. When owners/developers do not ask for a circular building, architects can advocate for circular design approaches. They can use educational materials developed in the precondition phase to demonstrate the value of circular building projects.

Although it is beyond the scope of this report to specify all the design and construction practices needed for circular building projects, some key initial actions can start moving the needle toward a CBE.

For **adaptive reuse**, architects can play a proactive role in identifying and suggesting buildings with high potential for reuse. In so doing, they should look at the value of the building itself and not just the cost of land. If the owner/developer client is open to suggestions, they may even be able to advocate for new builds to instead be adaptive reuse projects if they are able to find an existing structure that would meet the client's

needs. When it comes time to begin the adaptive reuse design, architects/engineers can use artificial intelligence scanning tools to assess existing buildings, overcoming the challenge of knowing what is within the walls when accurate blueprints are not available.

For **adaptive design**, architects/engineers need to make sure that buildings can be disassembled. They can do this by avoiding adhesives in initial construction and instead using building materials conducive to disassembly and disassemblable connection systems, which material manufacturers will hopefully bring to market in the precondition stages. Architects/engineers can design assemblies to access critical layers, which both makes disassembly easier and allows for more thorough maintenance during the building's lifetime. This more thorough maintenance in parts of buildings not normally easily reachable might make for easier adaptive reuse before it is time to disassemble the building. Working in an integrated design process with owners/developers and builders can help design teams identify opportunities for costing savings and efficiency, as well as with ensuring clarity in the building process when asking for non-standard designs. Emerging contractor-led approaches such as collaborative contracts and integrated project delivery with shared risk/reward models offer better systems of collaboration and communication and encourage project teams to explore innovations that will maximize project value.

Although circularity is not always feasible to achieve in buildings since fully disassemblable design can be prohibitively expensive, architects/engineers can make some simple design choices that allow for at least some future adaptability. For example, they can integrate design features that facilitate long-term updates to a given structure, such as including footings under the floor that allow for new interior walls in the future.

At the end of circular building projects, it is important that architects/engineers and owners/developers ensure that the appropriate documentation is complete to allow future reuse of the building or its materials. This includes updating building blueprints (especially important in adaptive reuse projects with pre-existing blueprints), documenting the overdesign elements that allow for later adaptation, specifying where disassemblable elements were used in the building, and indicating which materials are reused since their strength can degrade over time (ideally, reused materials' use and load history would also be known and documented). These records will help set up the preconditions for easier reuse, adaptation, and material recovery in the future.



Quebec

Web-Recyc offers a matchmaking platform for the direct transfer of used bricks between projects [18].

Second moves

The second moves will primarily be driven by fast followers implementing the first moves. As these actors join CBE coalitions in the precondition phase, they will learn how and why to implement circular design strategies in their building projects. They will have the benefit of success stories from the first moves, which they can learn from in their projects. These case studies can also be used by front-runners continuing to develop their circular design offerings. Ideally, these success stories will help architects more effectively and persuasively pitch circular building projects.

Additionally, the second moves are where **material reuse** will come into the design process. Deconstruction firms will play an important role upfront in the project planning by flagging materials that can be reused on-site in adaptive reuse projects or by working in an integrated design process at this stage to help more effectively design for salvaged materials or disassembly.

Details to include in communication of pilot success stories

The more details included in the communication of pilot projects, the more useful they will be for mobilizing future action. Specific particularly useful details include:

- The overarching strategy and, if relevant, the aesthetic principles
- What you did
- How did you do it?
- Who did you engage with?
- How your normal processes changed?
- How did you deliver differently (e.g. when working with the contractor and trades)?
- Impact
- Cost (capital cost for the budget? Longer-term operational life cycle costing?)
- Operations (maintenance, durability, and so forth)
- People who use the building
- Performance
- Material performance (e.g. same application as usual or something new)
- Structural performance (e.g. efficiency, resiliency, other criteria)
- Barriers to overcome/lessons learned, including transparency around what not to do
- What hurdles you had to overcome (e.g. city process policy, supply chain issues, working with a contractor)
- Contextual nuances for translating across Canada
- Local policies, climate, and so forth

6.3 Communicating and Celebrating Wins: Amplifying Actions

6.3.1 The Value of Project Success Stories

Once the circular building is done, the story does not end. Success stories can fertilize the operating environment to help others adopt circular building practices. They can offer inspiration, data on the performance of new approaches, and an overview of how they were done. Demonstration projects can even form the basis for future policy, which would give them an impact beyond incremental "project by project" change. The first moves in this space are to collect and write case studies with as much practical detail as possible. The second moves are to disseminate them through industry media, networks of municipalities, industry associations, and other networks.

6.3.2 General Principles

The way in which success stories are communicated can impact their usefulness as tools of inspiration and persuasion. A few overarching principles can make them more effective, which are described below.

First, communicating outcomes through as many lenses as possible will support the overall takeaways. Owners and developers will need to be convinced that emulating the pilot will reduce, or at least not increase, risks and costs and improve a building's performance. Contractors will need to know how the pilot was done. This will allow authorities with jurisdiction (e.g., municipalities) to learn what kinds of code and/or policy changes can remove barriers.

Second, it is important to include as much detail as possible, as described in the fictional scenario presented on page 31: "Imagining the future of circular building project." It is especially critical to make these principles translatable to different regional contexts to increase feasibility amid different policies, climates, building stocks, population needs, and the like. There is a tendency for a reflexive dismissal of case studies in their application to different contexts, such as "That can't work *here*." Although there is much to learn from abroad, especially Europe (e.g., The Netherlands, which informants told us has particularly innovative CBE initiatives), it is important to share successful pilot projects among Canadian actors so that actors

can access greater context and applicable information. As such, these lessons need to be translated into the Canadian context by key actors. Likewise, the differences between local contexts in Canada mean that pilots need to explicitly address regional circumstances; what works in Vancouver may initially seem irrelevant in Toronto, Montreal, or Halifax, although central elements can be applied across regions.

Third, when appropriate, the aesthetics of circular design should be celebrated. In particular, architects tend to be motivated by opportunities to flex their creativity and design something beautiful. As much as possible, circular design should be framed as attractive and an opportunity to infuse creativity and design.

Finally, it could be beneficial to acknowledge that prices in a pilot project may have been higher than if there were economies of scale. For example, niche materials or parts that enable circularity will likely become less expensive over time as they become more mainstream and accessible.

6.3.3 Collecting and Disseminating Success Stories

Various actors can play an important role in collecting and disseminating success stories. For instance, it may be beneficial for one enabling actor, such as a CBE NGO, to take the lead on collecting and disseminating pilot cases. They could collaborate with architects, owners, and developers to identify exciting pilots, giving those actors the benefit of publicity. Industry associations, media, and conferences can also play a key role in sharing these stories.

The success stories should be mobilized through numerous channels and media, including magazines, trade shows, seminars, podcasts, and YouTube channels. It is important to reach industry actors, such as owners, developers, architects, and engineers, where they are—especially for those not seeking out information about circular building approaches. Additionally, it is critically important to reach industry actors not explicitly positioned as CBE firms. The fast followers among this group will be instrumental in creating momentum and involving more skeptical industry actors.

6.3.4 How Might Pilot Case Studies Be Used?

Case studies showcasing successful pilot projects can activate actors in a variety of ways.

Architects often use cases to demonstrate to clients what is possible. They can utilize case studies with owner/developer clients reactively if the client asks for circular approaches or proactively in pitching their initial vision presentations at the beginning of the engagement when the client is most open to ideas. The most progressive clients may want to go beyond emulating pilot cases to instead "leapfrog" them and position themselves as innovators in the space.

Owners/developers may use them to figure out how to implement circular strategies. They can pass along detailed case studies to their contractors, who in turn can use that information to explore how they can implement that solution. Having this information in one place can save time.

Municipalities can share their experiences with one another (e.g., model bylaws, policies, and programs to accommodate existing buildings) and translate success stories into their local contexts. Existing networks, such as those among the municipalities of Metro Vancouver or the Canadian Circular Cities and Regions Initiative, are good places to exhibit this kind of knowledge sharing.

CBE NGOs can collect and/or disseminate pilot case studies as part of their mobilization work.

7 Mobilizing Action in the Future

7.1 Ongoing Engagement and Emergence

In moving forward to mobilize the actions laid out in this report and the companion report written by SCIUS Advisory, we recommend maintaining an ethos of flexibility and adaptation [1]. Transforming the built environment is a complex systems problem in an unpredictable operating environment, making it essential to evaluate and adjust over time. However, building projects' lengthy timelines should be factored into the timing of feedback and evaluation points.

Imagining the future of circular building projects

How could the pieces in this action plan work together in practice? Here's one fictional scenario that will hopefully become reality:

In Canada, Developer X wants to create a new office building in City Y. They look into existing locations for their project and find a location where a small mall exists but is closing down. The Developer examines the building's specs and learns that its location and size may work with their plans, so they consult with an architect to identify opportunities for adapting their plans to be accommodated within the existing structure. They connect with City Y and learn about the special building permit allowed for circular projects. The architect realizes that a portion of the building will need to be replaced and reaches out to an NGO for recommended resources to achieve circularity in this part of the project. Together, they identify a demolition company that will disassemble most of this section. The remaining sections will be adapted for the new office space, and a manufacturer is identified that has started creating disassemblable fittings so that the new section can be adapted down the road. After the renovation is complete, the architect and owner agree on how to store and maintain the building records for the future. The NGO works with the project team to write up and share a case study on this project.

To make true systems change, it is important for initiatives to "scale up" and "scale deep" so that future configurations can emerge. *Scaling up* in the systems change context is the adoption of the initiative not just by a few isolated actors but also actors that span geographies and sectors. *Scaling deep* happens when actors embed these ideas deep in their practices and psyches, changing what systems theorist Donella Meadows calls a group's "great big unstated assumptions" [23].

As systems change is hard to predict, it is important that numerous high-profile initiatives show both the viability and benefits of circular building projects. In complex systems, new patterns (e.g., industry trends) emerge over time due to interactions between individual components (e.g., actors) and as more actors adopt new behaviours that can move the entire system forward. As such, systems-wide change can be driven by success stories upon which other success stories can build. The more visible CBE projects are, the less such buildings seem like clever one-offs. This is the approach of nudges and experiments characteristic of systems change.

To do this, we recommend balancing top-down alignment and bottom-up emergence. This means having a central actor (or actors) leading the mobilization efforts and aligning organizations for collaborative action, while simultaneously making space for the discrete needs of organizations within the coalition.

It is particularly valuable to regularly have synchronous engagements with coalition organizations. These should include time for facilitated interactions that allow participants to adapt and build upon one another's ideas. This means that when CBE coalitions meet, their meeting agendas should not just comprise information dumps but rather include time for dialogue and ideation. Coalitions should also hold workshop sessions when making plans for new initiatives or building broader strategies for systems change. These workshops should have focused goals, utilize relatively small breakout groups, and leave time for discussion and reaction. Flexible visual tools, such as sticky notes, should be used so that participants can move, add to, cluster, and build on one another's ideas.

7.2 Actors to Target

To transform the system, we recommend first engaging front-runner organizations and individuals already promoting circular building approaches. The next target should be fast followers, organizations and individuals that are interested in some aspects of circularity in buildings but have not shown external leadership on the issue. These actors will be more difficult to identify than explicitly circular ones, which is why it is important to bring CBE messages to broader industry audiences with clear avenues for engaging (e.g., joining a CBE coalition or participating in workshops) so that these people can make themselves known to initiative leaders.

In our research, we found that actors outside of the CBE forerunners are already thinking about these issues, though not necessarily using the term "circularity." For example, we heard from a representative of a real estate company that develops and owns residential and commercial properties:

> *The biggest [issue] that comes up often in my world right now is really understanding how we can future-proof our new builds . . . What are people going to need in 30 years? We don't have a crystal ball to do that but finding ways to design the space with more open corridors, less structural walls, etc., we have more flexibility with redesigning or even selling the building in the future.*

Even though the term circularity is widely known, it does not necessarily resonate widely among industry actors. Outside of a few front-runners, most industry actors believe that a CBE will add more work, add more time, and involve more people. Further, a CBE also evokes images of practices related to the end-of-life of buildings, rather than images of increasing the use life of buildings.

We recommend that more salient descriptors than circularity be foregrounded when communicating with built environment industry actors. Concepts like future-proofing and affordability connect to broader discussions already happening in the industry and society more broadly. They will therefore likely result in wider engagement from industry, as circularity seems to be unfamiliar for those outside of front-runner CBE organizations. Thus, the coalition of the willing may be larger than it seems.

In the short term, agile actors in the front-runner and fast follower categories with agency to influence design and development processes, such as architects whose clients give them wide latitude to freely make design choices, will likely be the most effective agents of change. Oftentimes, actors newer to the field (e.g., new graduates) are more forward-looking and more likely to embrace CBE. Those rising into leadership positions, such as architecture firms' junior partners, are particularly salient levers of change. The most effective actions for these groups will have the fewest touchpoints with other actors, decreasing the likelihood of roadblocks.

Larger actors (such as the federal government, large corporations, and large industry associations) are often slower to act, but they play an important role in setting values, incentives, targets, and language. They also have tremendous purchasing power and can lead by example with their own projects. For example, federal green procurement initiatives can send market signals that trigger the development of new products that fit their requirements. Smaller actors, such as small corporations and municipal governments, can often move more swiftly.

7.3 Prioritizing Actions

As a concrete roadmap is developed in the next phase of this project, we recommend prioritizing actions based on:

- their ability to lift barriers and/or capitalize existing enablers, identified in the Awareness Mapping phase of the Compass methodology (see Section 9.2);
- how they connect to the three social outcomes of affordability, profitability, and/or climate resilience; and
- their potential to inspire others to try similar approaches.



The third point may seem nebulous, but it is particularly important. Ultimately, the system needs culture change in both the industry and among consumers to move away from the expectation of always building new. Leveraging pilot projects can make new approaches visible, definable, and imitable, ideally leading to the normalization of circular innovations and shifting the culture.

In moving forward, these prioritization principles can be employed and refined to identify which specific actions outlined in this report and the corresponding Phase 1 report written by SCIUS Advisory to implement [1].

Although changing a complex system like the built environment is difficult, we see points of optimism. Given the eager engagement in our workshops and interviews, there is clearly energy in this space. We have seen this energy particularly among younger actors who will be the future leaders, boding well for a culture shift toward a CBE.

7.4 Future Research and Exploration

As CBE initiatives are implemented, there will be a continual need for new areas of research and application. Through the process of collecting feedback on this report, we have identified areas that may be particularly fruitful for future research.

First, future research should more deeply investigate the role of information and communication technologies in the CBE transition. Particularly fruitful areas of technology research include the creation and leveraging of digital assets; the development of digital collaboration platforms; and the application of artificial intelligence, machine learning, internet of things, and robotic technologies. It is likely that new enabling actors will emerge as these technologies and their CBE applications continue to mature.

Second, more research could be done on potential roles of other actors in the system. For example, city planners can play an important role as enabling actors, and future research can explore how to ensure that they are more aware of CBE prior to making critical planning decisions affecting all other downstream actors. Additionally, further research can dive into the nuances of relationships and communication channels between actors in the system, especially in governmental agencies that may have jurisdiction over different aspects of CBE (e.g., city planners and procurement specialists).

Finally, future research can delineate how to mobilize CBE technical expertise most effectively. For example, SDOs can create technical subcommittees with the engineering and industry expertise to address some of the barriers, and SDOs and government bodies can embed CBE experts into technical committees for code development, standards, and so on.

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9 Appendices

9.1 Data Sources and Report Writing

Advancing the CBE is a systems problem, so to inspire change, we need a systems approach. To identify a roadmap forward for the CBE that is novel, actionable, and has longevity, we worked through the four spaces of our Compass methodology. We used desktop research, interviews, and workshops to inform our understanding of these spaces.

9.1.1 Desktop Research

SCIUS Advisory completed Phase 1 of this project [1]. They conducted a deep environmental scan that we used to inform our work. Our team supplemented this research with other key reports on the CBE in Canada and abroad; industry trade publications, websites, and webinars; and academic research on circular design and materials [2], [6], [7], [24]-[34]. Additionally, we referenced relevant existing material and construction standards in Canada [8]-[11].

9.1.2 Interviews

Our team conducted 25 one-hour virtual interviews that gathered insights from 30 informants. These interviews included direct actor representatives from various stages of the building life cycle: development, design, construction and end-of-life. They also included conversations with representatives from the enabling actor's group, such as NGOs, municipalities, and industry associations. Interviewees intentionally had varying degrees of knowledge and engagement with circularity concepts. These interviews allowed us to better understand the system and build our awareness.

9.1.3 Workshops

Our team conducted four workshops—three virtual and one in person. The three virtual workshops were organized around materials: wood, steel, and concrete. As such, they included actors distinctly involved with each material as well as cross-cutting voices across the value chain. Forty-nine people participated in the virtual workshops. The in-person workshop was held at CSA Group's office in Ottawa and was attended by this project's SAC. Fourteen people participated in the in-person workshop. All four workshops were critical for generating ideas and actions.

9.2 The Compass

At Innovation North, we take a systems-based approach to innovation. We have co-created a tool, the Compass (image on the right), with researchers and business leaders from across Canada. The Compass is made up of four spaces: Problems, Awareness, Ideas, and Actions. We move through these spaces, iterating back and forth as necessary.



Problems:

We define a problem as the gap between the current situation and a desirable future. In systems innovation, there is rarely a single problem or a "right" problem. Rather, there is an "ecology of problems"—a set of interrelated problems that cut across societal and organizational systems.

Awareness:

Building awareness reveals the structure and forces that shape the systems surrounding the problem, helping to identify the risks, barriers, and enablers to change. We ensure that our awareness building is thorough, inclusive, and comprehensive by engaging with key actors through interview conversations and highly interactive workshops. This creates space for us to gain perspectives from actors directly working within the relevant space.

It is important to note that we do not only include the actors that may seem most obvious during this stage; we widen our scope to gain as many perspectives as possible to build out our awareness holistically. Through the insights gained, we build a map of the system that identify barriers and enablers to change.

Ideas:

Ideas are potential solutions or opportunities that can address the problem(s). In this space, we generate numerous ideas or solutions and sort them based on our partners' priorities and preferences.

Actions:

Actions are the effort taken to solve the problems. Actions can include almost anything, such as changes to communications, language, operations, corporate identify, and new partnerships or alliances. Similar to the Problems space, we identify an ecology of actions, a cohesive set of short-term actions that can influence a system in the long run.

CSA Group Research

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

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