# A SWOT Analysis for Deconstruction of the Canadian Built Environment

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**Abstract.** Massive amounts of Construction, Renovation, and Demolition (CRD) waste are produced from the construction sector. The circularity of the construction is gaining momentum for controlling and reducing the stream and amount of CRD waste. To this end, the deconstruction concept, i.e., a planned disassembly of components and materials of the built facility, has emerged as a more resource-friendly alternative compared to demolition. The transition towards deconstruction requires radical changes in the current practices of the construction industry. To this end, this research assesses the readiness of the Canadian construction industry to adopt deconstruction. The research followed a three-stage methodology that includes Deconstruction in Utopia, Canada Status Quo, and Canada Readiness for Deconstruction Adoption. Deconstruction in Utopia proposes the ideal scenario for the extreme implementation of deconstruction; Canada Status Quo analyzed available data in the context of deconstruction in Canada. Finally, Canada Readiness for Deconstruction Adoption was investigated by analyzing the positive and negative external and internal factors affecting the implementation of deconstruction through Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. The paper discussed the challenges and barriers to overcome for the transition to deconstruction and highlighted the potential of the National Building Code (NBC) of Canada and Leadership in Energy and Environmental Design (LEED) to support deconstruction. The output of this paper can aid policy-makers in setting strategies to boost the implementation of deconstruction as an End-of-Life (EoL) scenario.

**Keywords:** Circularity in Construction, Deconstruction, Canada Readiness, SWOT analysis.

## 1 Introduction

The construction industry has been identified as one of the largest consumers of virgin materials and a major contributor to landfills through Construction, Renovation, and Demolition (CRD) waste [1]. It is estimated that the construction industry is responsible for more than 30% of the world's total waste, and it consumes around 50% of the world's virgin materials [2]. These alarming statistics highlight the urgent need to re-evaluate and change the current practices in the construction industry [3], [4].

The current practices in the construction industry follow a linear supply chain model (take-make-dispose) with minimum consideration of the End-of-Life (EoL) phase of the built facilities [5]. There is a dire need to change the current linear economic model, to a circular economy that aims to keep resources in use for as long as possible, minimizing waste and environmental impact [6]. Adopting CE in the construction industry is highly dependent on the way of handling the components of the built facility at the End of Life (EoL) stage [7]. Two most common EoL scenarios are *demolition* (i.e., the act of destroying a built facility regardless of its capacity for second life and landfilling most of the generated waste with little consideration for recycling or reuse); and *deconstruction* (i.e., the process of dismantling a building and salvaging materials for reuse or recycling) [8].

Deconstruction presents a primary enabler for the transition from a linear to a CE in the construction industry. It not only reduces the amount of waste generated by demolition but also provides a source of valuable building materials for reuse in future construction projects. However, implementing deconstruction practices requires radical changes in the construction industry [3]. The traditional approach of building for a predetermined lifespan must be replaced with a more flexible approach that allows buildings to be disassembled and materials to be reused. This will require the industry to adopt new business models and technology that prioritize deconstruction and the CE.

Despite the potential benefits of deconstruction, implementing deconstruction is still in its infancy stage. Moreover, studies assessing the competitive position of the construction industry to adopt deconstruction practices are scarce, if any. This gap in knowledge presents a significant challenge in understanding the potential barriers to the adoption of deconstruction and identifying strategies to overcome them. Therefore, this paper aims to fill this gap by analyzing the readiness of the construction industry to implement deconstruction as a means of transitioning from a linear to a circular economy.

## 2 Methodology

The authors adopted a three-stage research methodology. In the first stage "*Deconstruction in Utopia*" the ideal scenario for implementing deconstruction was proposed. To do so, the perspectives of industry practitioners and researchers towards the transition to deconstruction were analyzed. The body of empirical research (i.e., publications that utilized interviews, surveys, or focus groups on their research) was used to get the barriers and enabling factors for implementing deconstruction from an industry viewpoint, while technical papers were reviewed to analyze the latest methodologies and cutting-edge technologies that researchers are proposing to foster deconstruction adoption. The analyzed articles were extracted from a dataset of the deconstruction body of knowledge published in a previous study [3].

In the second stage "*Canada Status Quo*", research and analysis of available data in the context of deconstruction in Canada, including government statistics, regulations, standards, guidelines, upcoming events, current practices, infrastructure availability as well as the use cases of the CRD waste. Finally based on the first two stages, "*Canada Readiness for Deconstruction Adoption*" was addressed by analyzing the external and internal factors (positive and negative) affecting the implementation of deconstruction at the end-of-life of built facilities through Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. SWOT analysis has been formerly used in the waste management sector to assess the competitive position of municipalities and countries for better management of waste [9], [10]. The SWOT analysis of this study is focused on the implementation of deconstruction in the Canadian construction industry.

## 3 Deconstruction in Utopia

After analyzing the deconstruction body of knowledge and the perspectives of industry practitioners, the ideal scenario for implementing deconstruction "Deconstruction in Utopia (DiU)" was proposed, as shown in Fig. 1; three main pillars are shaping the DiU, i.e., (i) *Deconstructability* as the ability of a facility's components to be disassembled and recovered; (ii) *Capability* which entails the knowledge, expertise, resources, and infrastructure required for deconstruction and post-deconstruction processes; and (iii) *Marketability*, i.e., the market demand for the reclaimed components/materials.

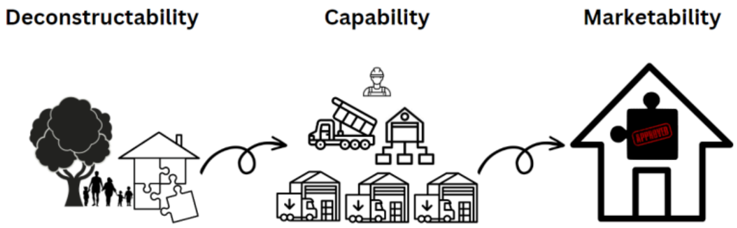


**Fig. 1.** Criteria for defining Deconstruction in Utopia

To begin with, the research community focuses on deconstructability as a design criterion for new construction and a decision-making criterion for the existing built environment. Research efforts at the design phase have been concerned with developing a quantitative approach for architects/ designers to assess the deconstructability of their designs such as the Deconstructability Assessment Score (DAS) [8]. The scoring system of this approach depends on considering the Design for Deconstruction (DfD) principles in the design process; for instance, using prefabricated components, dry connections, and components/ material that have potential for reuse/ recycle at the EoL of the built facility. The second research line, which focused on the EoL phase, shows that deconstructability is an important criterion to decide whether to deconstruct the component and what the most proper deconstruction method is [11]–[15]. The method of implementing deconstruction will affect the destiny of the disassembled component. For instance, performing ‘perfect deconstruction’, i.e., disassembly of the components with nearly zero damage, augments the opportunities for reusing the deconstructed component. In contrast, applying ‘destructive deconstruction’, i.e., breaking apart the components without considering damages, will increase the likelihood of being left with no options other than recycling, downcycling, or even landfilling the disassembled components [3]. Industry practitioners have also confirmed the necessity of having deconstructable facilities to implement deconstruction instead of demolition; they mentioned that one of the major barriers to deconstruction and circularity adoption is that the existing built environment is not designed to disassemble [16]–[18].

The research attempts to facilitate deconstruction implementation were not only focused on assuring the deconstructability of the built environment but also on the readiness of stakeholders and infrastructure. For instance, the ability of contractors to implement deconstruction processes and the capacity of infrastructure to manage the deconstructed components including storage spaces, transportation, and treatments plants ‘post-deconstruction’ processes. The contractor’s capability involves the *technical skills* and *resources* required to carry out the deconstruction process effectively and safely [12], [14]. In this realm, a research line was established to plan the sequence of deconstruction activities to minimize the number of parts to be disassembled [11], [19]. Furthermore, resource management has been the subject of other studies in deconstruction planning due to its significance in carrying out deconstruction tasks safely and in a timely manner (deconstruction and loading time), without any interruptions or risks [7], [12], [13], [15]. From the cost management point of view, the research investigations were not only concerned with the onsite costs (preparation, deconstruction, and loading cost) but also the cost associated with post-deconstruction processes (treatment cost, taxes, penalties, and resale value) [7], [13], [20], [21]. While the environmental performance of deconstruction and post-deconstruction processes is on researchers’ agenda through assessing the environmental impact of deconstruction activities, transportation, waste processing, and reassembling the reclaimed components [15], [22]. Further, industry practitioners were in harmony with the research community about the importance of capability for the transition toward the deconstruction of the built environment. Lack of infrastructure capacity, expertise, and knowledge is always on the top of the list of barriers to adopting circularity in the construction industry [4], [16]–[18].

Last but not least, marketability refers to the demand for the reclaimed components/ materials as well as the economic viability of the deconstruction adoption. Marketability is gaining momentum as the most important enabler for adopting deconstruction in the construction industry. Researchers in academia addressed marketability by identifying the potential customers for reclaimed components and/ or materials as well as introducing marketing strategies to change the negative perception of the market towards second-use components/ materials [12], [14], [23]. The negative perception comes from doubts about the technical and aesthetic performance of reclaimed components/recycled materials. Also, the early engagement of potential customers was addressed by researchers to match the supply (reclaimed components/ materials) and demand (new construction) [23]. Several experts from the construction industry with different backgrounds and experiences agreed that marketability is the primary liaison between the deconstruction of the built environment and new construction. They believe that solving the following barriers will increase the potential for implementing deconstruction in the construction industry [4], [16]–[18], [24]: (i) negative social stigma of reused products; (ii) aesthetic performance of reused products; (iii) durability issues of reused products; (iv) supply and demand matching; (v) certifications and accountability of reused products; (vi) lack of coordination between stakeholders; (vii) underdeveloped markets of the enablers for circularity in construction (e.g., prefabrication and modular construction); and (viii) uncertainties about the future needs (i.e., obsolescence of components/ materials due to change in regulations).

Reaching DiU scenario requires radical changes in the current practices of design, construction, operation, and EoL phases, supply chain, as well as the business model of the construction industry. In the following section "*Canada Status Quo*", the current situation of the construction industry in Canada will be assessed, and in the "*Canada Readiness for Deconstruction Adoption*" section to how far the construction industry in Canada is from DiU and how difficult it will be to get there.

## 4 Canada Readiness for Deconstruction Adoption

In Canada, the CRD waste, makes up one of the largest streams of solid waste. According to last published waste management survey in Canada, 4 million tons of CRD waste was generated and only 16% of that was diverted from landfill through recycling [25]. Almost 90% of the generated waste by the construction industry is dependent on the renovation and demolition activities [26]. With recent implementations of bylaws requiring building upgrades to achieve better energy performance, the waste stream coming from the CRD may increase in the coming years [27]. However, adopting deconstruction as an alternative to demolition of the built environment can potentially save up to 2.5 million tons of waste [28]. Yet, as previously seen in the "*Deconstruction in Utopia*" section, the transition towards deconstruction involves the decisions made and practices adopted throughout the facility's lifecycle as well as the afterlife (second-life and beyond) of the disassembled components/ materials. In this realm, the internal and external factors in Canada that can boost or hinder this transition were investigated under three axes to assess the status quo of Canada. The three axes include the "vision"; "legal framework"; and "existing resources", and they will be further explained in the following subsections.

### 4.1 Vision

The country's vision was manifested in the published reports about circularity in Canada [28]–[31]. After analyzing those reports, it can be theoretically stated that Canada is moving towards adopting circularity in construction. For instance, the vision of the city of Vancouver is to become a zero-waste community by 2040. This vision was manifested by expanding the green demolition (i.e., reuse and/or recycle demolition waste) by-law from pre-1940 homes to pre-1950 homes [31]. It should be noted that under this by-law, reuse practices gain more credits recycling [32].

The reports also highlight the potential environmental and economic benefits of adopting circularity in the built environment sector and provide recommendations for closing the circularity gap. The reports identify several challenges and barriers to circularity in construction, but also provide examples of successful circular initiatives in Canada. For instance, implementing circular strategies such as adaptive reuse (i.e., repurpose the basic structure of the building and reuse the disassembled components/ materials) and Design for Disassembly (DfD) can avoid 106,000, and 2.5 million tons of the annual waste produced by the Canadian construction sector, respectively. Adopting these circular strategies can improve the employment rate because of their labor-intensive nature and the creation of new markets 'reused products'.

Hosting exceptional events like the next World Cup (2026) may give Canada an opportunity to promote circularity in construction [33]. Since significant upgrades and renovations of the stadiums hosting the matches (BMO Field in Toronto and BC Place in Vancouver) are necessary to meet FIFA requirements [34], circular strategies can be implemented to be an exemplar of circularity in construction. For instance, in the last World Cup (2022), Qatar introduced stadium 974, which is the world's first fully demountable soccer (football) stadium, made from shipping containers and modular steel [35]. Now, the containers and super-structure will be reused for waterfront development, providing excellent facilities for the local community and a dynamic hub for businesses, emphasizing the importance of circularity in construction.

### 4.2 Legal Framework

When it comes to the second axis (legal framework), the system of laws, regulations, policies, and guidelines that establish the rules and principles for deconstruction throughout the lifecycle of the facilities were reviewed. To begin with, the National Building Code of Canada (NBC) is a model code that sets out technical provisions for the design and construction of new buildings. It is intended to ensure the health and safety of building occupants and the general public, as well as the conservation of energy and the protection of the environment [36]. Although NBC does not have a section about deconstruction, considering Factory-constructed Buildings (Offsite Construction) and accepting reused products may boost the implementation of deconstruction of the built environment. Factory-constructed buildings not only facilitate the deconstructability of the built facility but also the marketability of the disassembled components. The requirements of the onsite construction according to NBC apply to the offsite construction by following the procedures of the Canadian Standard Association (CSA) group for prefabricated buildings [37]. Along the same lines, the requirements for reused products are the same as new products. Using reused products may present challenges as testing them using the same procedures as new products can be costly and time-consuming, particularly if the sampling methods are not compatible with reused materials.

Adapting the current codes could encourage the adoption of deconstruction. As durability issue is one of the barriers to provide easy-to-disassemble buildings, CSA issued a standard so-called CSA S478 that provides criteria and requirements for designing durable buildings [38]. Also, a recent change in building codes across the country (NBC) has made it possible for mid-rise construction of up to six stories to have a wood frame [39], which may not directly facilitate deconstruction but it will influence the type of waste stream of materials to be available in the second-use material market in the long run.

On the certification side, Green Building Rating Systems (GBRS) such as Leadership in Energy and Environmental Design (LEED) offers certifications for buildings that meet specific thresholds. On the one hand, following design for flexibility principles (i.e., ease of future adaptation of the proposed design at the EoL phase) gives credits to the proposed design under Material and Resources category. However, as of 2022 these credits are limited to designs related to the healthcare systems [40]. On the other hand, preparing a construction and demolition waste management plan to prevent and/or divert the waste gives the proposed design more credits under Material and Resources category. Though rating systems are not usually mandatory, in 2014, LEED-certified buildings corresponded to 10.7% of all new construction floor space in Canada [41]. Yet, LEED certification is not mandatory and buildings owners can choose to pursue LEED certification as a voluntary means of demonstrating their commitment to sustainable design and construction practices.

On the guideline side, the International Organization for Standardization (ISO) and CSA provide standards (ISO 20887 and Z782-06) that include guidelines to the principles of Design for Disassembly and Adaptability (DfD/A) and potential strategies for integrating these principles into the design process [42], [43]. It also includes guidance on measuring performance regarding each DfD/A principle and related objectives. Though these documents are not mandatory in Canada, their existence provide great opportunity for future building designs.

Controlling and reducing the stream and amount of CRD waste not only requires making decisions at the design stage but also managing the onsite processes. To this end, two main approaches can be followed while implementing onsite activities in Canada. The first approach includes the adoption of bylaws that require the generators (i.e., building owners and contractors, designers, builders, demolition contractors) to manage the waste that they are producing. For instance, in the City of Vancouver, all waste material on a construction site must be sorted if the project value is $50,000 or more [27]. Another example adopted by the municipalities of the Metro Vancouver area is the requirement of developing a Waste Disposal and Recycling Services Plan as part of the construction and demolition permit process [44]. The second policy approach includes the adoption of recycling or diversion targets. The city of Port Moody and the Halifax Regional Municipality, e.g., have adopted a mandatory diversion target of 70% and 75%, respectively [45], [46]. The City of Toronto took a slightly different approach, with the creation of a LEED inspired certification, the Toronto Green Standard, a requirement for recycling 75% of CRD waste was implemented on a non-mandatory basis [47]. While waste diversion approaches have contributed to reducing the volume of waste that ends up in landfills, the reuse of materials and products is still not widely adopted. One of the challenges is the ambiguity in defining what constitutes reuse and how it differs from recycling. While recycling involves processing waste materials to create new products, reuse involves directly using items that have already been manufactured, possibly with some repair or modification. The lack of clear guidelines and standards for reuse can make it difficult for industries to implement deconstruction.

### 4.3 Existing Resources

Last but not least, available resources in Canada to adopt deconstruction were analyzed. The keystone for the success of adopting deconstruction is the information sharing and coordination between stakeholders. Building Information Modeling (BIM) can be used to create a digital Material Passport that provides information on the composition and location of building materials and components, facilitating the deconstruction and reuse of those materials [48]. In this realm, the diffusion of BIM in the Canadian construction industry was analyzed. Between 2018 and 2020, a survey revealed that nearly 30% of the projects undertaken by Canadian contractors did not use BIM. Although BIM has great potential to better manage the processes throughout the entire lifecycle of the facility, BIM mostly tends to be used only during the design stage, resulting in a loss of information during the EoL phase [49]. Yet, several companies currently offer 3D reconstruction services in the Canadian market, that help bridge the gap between the digital and physical realms and enable the revitalization of constructed facilities during the EoL phase.

The main element to boost the transition towards the deconstruction of the built environment is the willingness of stakeholders to perform the change [50]. The Canadian construction industry is progressing, several companies currently offer circular design services, modular construction services, Recycled Concrete Aggregate (RCA), and dismantling buildings services [30]. Also, the capability for diverting the waste produced from the landfill is highly dependent on the waste management system in place. Today, in Canada, the available processing facilities can process mixed CRD waste, wood, drywall, asphalt shingles, and CRD aggregates, which covers a significant portion of the different types of CRD waste generated [26]. The main issue with the existing facilities, however, is related logistics. For instance, there are only three facilities for processing asphalt shingles in the whole country (British Colombia, Saskatchewan, and Manitoba) [26]. Thus, it can be very impractical for asphalt shingles waste produced in different provinces to be processed in these locations.

In addition to the primary impact of a waste management system which is the waste diversion performance, these systems can also impact on a social and economic level. Municipalities across Canada have spent over $3.2 billion on their waste management systems in 2012 [51], and that enabled them to provide over 4,800 jobs [41]. Though that may not seem to be a lot when looking at the whole country, this number tends to increase since it is estimated that for every 1,000 tons of waste being diverted, 7 new jobs are created [52]. And since some provincial governments (e.g., Québec) are providing incentives to municipalities to improve their waste management performance [53].

The last step to enable the adoption of deconstruction practices has to do with the available market for the material and components waste being generated. The waste can be generally classified under four main categories. The *high value waste* is the waste that can be reused or easily recycled; *simple to divert* is the waste that can be diverted with some level of financial support; *complex to divert* is the waste that require a more complex option for diversion that may need significant financial support; and *limited options* is the waste that cannot be diverted at current capability level [39]. High value waste (e.g., steel beams and columns, doors) are generally salvaged by demolition contractors prior to demolition and taken to antique stores, reuse centers [54]. There is high demand for good quality antique or vintage architectural salvage. When it comes to the simple and complex to divert waste (e.g., clean wood, concrete, asphalt roofing), the value of the material is highly dependent on the maturity of the market [55]. For instance, while aggregates and asphalt paving have a well-established recycling market within the construction industry, other materials such as drywall may have the opportunity to be used in the construction or paper industry during their second-life but this market still needs support to mature. And lastly, the market opportunities for the limited options waste (e.g., materials that cannot be separated such as painted wood) will be highly dependent on the condition and the level of contamination of the material. In most regions, there are limited markets for these types of waste, if any [39].

### 4.4 The SWOT Analysis

Overlaying the DiU and Canada Status Quo showed how far/ close the Canadian construction industry from adopting deconstruction as a viable alternative to demolition. In summary, Canada has internal and external factors that may boost/ hinder the transition towards deconstruction. Fig. 2 shows the SWOT analysis as an initial understanding of the competitive advantage of deconstruction in the Canadian construction industry. Strengths represent factors that give an advantage in implementing deconstruction in the built environment; Weaknesses refers to factors that may hinder the adoption of deconstruction; Opportunities shows potential benefits and new avenues that could arise from implementing deconstruction; and Threats shows factors that could impede the adoption of deconstruction or make it less appealing.

Overall, the SWOT analysis showed that adopting deconstruction and circularity in the Canadian construction industry has the potential to provide significant benefits in terms of CRD waste reduction and new business opportunities. However, there are also significant challenges such as low rates of waste diversion, lack of support in building codes, and an immature market for reused products. The opportunity to achieve Sustainable Development Goals and promote circularity during the World Cup 2026 should also be considered.

## 5 Conclusion

The transition towards deconstruction is gaining momentum, primarily due to the enormous amount of waste generated by CRD activities. While Canada is moving towards adopting circularity in construction and transitioning towards deconstruction, there are still challenges and barriers to overcome. Deconstructing the built environment requires a vision, legal framework, and existing resources that support this transition. The Canadian NBC and LEED have the potential to support deconstruction, but some shortcomings still exist. Additionally, hosting international events like the 2026 World Cup can be an excellent opportunity for Canada to promote deconstruction as a viable alternative to demolition after the tournament.

The main contribution of this paper is providing insight into Canada's readiness to adopt deconstruction in the construction industry by overlaying DiU and Canada Status Quo. The results of this study are of interest to policymakers who need to make strategic decisions to push the construction industry in Canada towards circularity. However, this research has some limitations; the economic viability of implementing deconstruction as an alternative to demolition was not investigated, and stakeholder management was not within the scope of this study. Accordingly, the future studies should develop strategies for managing stakeholders to ensure their participation and support in the process. The next step of this research is to develop a conceptual model to alleviate the cur-rent weaknesses and threats and foster the identified strengths and opportunities by incorporating People, Process, Technology (PPT) in the change process.

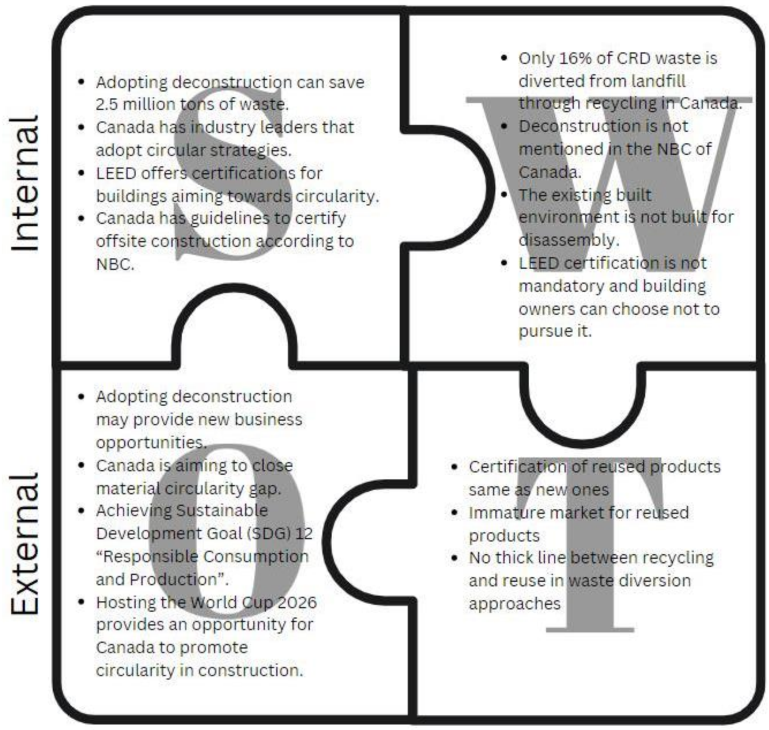


**Fig. 2.** SWOT analysis of adopting deconstruction in Canada

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