CIRCULAR SOLUTIONS TO WOOD WASTE

SBL CONSULTING PROJECT FINAL REPORT

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Executive Summary

The National Zero Waste Council (NZWC) Construction, Renovation, and Demolition (CRD) Working Group engaged the Circular Roots Collective (CRC) through the Sustainable Business Leadership (SBL) program at British Columbia Institute of Technology (BCIT) to address the challenge of reducing wood waste in the CRD sector. CRD wood constitutes a significant portion of post-consumer wood sent to landfills, with only a fraction being reused. This report identifies solutions to reduce linear wood disposal, discovering circular economic opportunities, emphasizing resource recovery, reuse, recycling, and design strategies to extend the life cycle of wood materials in the CRD industry.

Methodology

The Circular Roots Collective undertook desk research and expert interviews to understand current practices and challenges in wood recovery within the CRD industry and to identify successful factors. Desk research involved analyzing extensive literature, industry reports, and case studies on global best practices in circular wood practices. Expert interviews included in-depth conversations with 16 stakeholders, including industry experts, environmental organization representatives, and CRD practitioners.

The Existing CRD Landscape in the Metro Vancouver Region

One-third of the waste sent to landfills in the Metro Vancouver region originates from CRD activities, with wood waste comprising nearly 48% of this category. In 2022, wood made up 65% of the C&D waste at the Vancouver Landfill (VLF). Primary components included dimensional lumber (32%) and composite plywood (21%). The private landfill Ecowaste Richmond also reported significant wood waste, with 42% being salvageable.

Key Findings

Barriers: Economic disincentives favor disposing of wood due to the low cost of raw wood versus high recovery labor costs. Inconsistent regulations and a lack of unified policies hinder sustainable wood management. Logistical hurdles, construction schedules, and a lack of knowledgeable staff impede efficient wood sorting. Perceptions of "waste" limit resource reuse.

Success Factors: Advanced sorting systems and Design for Disassembly (DfD) are key innovations with potential to reduce CRD wood waste. Advanced sorting improves accuracy and reduces labor issues, while DfD facilitates material reuse by enabling easier deconstruction for the future. MDF recovery was deemed economically unviable due to material composition and lack of specialized recycling infrastructure.

Circular Innovations: An integrated approach combining technological innovation, comprehensive policies, economic incentives, and educational initiatives is essential for scaling circular innovations. Advanced sorting technologies and DfD should be incorporated into building codes, supported by digital tools for tracking, prefabrication, and modular design. Standardized policies, financial incentives, and cross-sectional stakeholder involvement are crucial to advancing circularity in the built environment.

Recommendations

The recommendations below are categorized into findings that apply to policymakers and CRD business practitioners:

Source Separation: For CRD business practitioners, adopting advanced sorting technologies and creating market demand for upcycled wood are key. Supporting deconstruction businesses and enhancing education and training will further promote sustainable practices. For policymakers, implementing standardized policies, providing economic incentives, and imposing fines for non-compliance are crucial. Encouraging community involvement and partnerships with local businesses will also drive improvements.

Design for Disassembly (DfD): For CRD business practitioners, utilizing Building Information Modeling (BIM), promoting homogeneous materials, and supporting prefabrication and modular design will enhance material recovery and extend the lifecycle of building components. For policymakers, incorporating DfD principles into building codes, supporting digital modeling technologies, and offering financial incentives like tax breaks will encourage DfD adoption. Requiring Life Cycle Assessment (LCA) reporting ensures sustainable construction.

Conclusion

By advancing a multifaceted approach and adopting technological innovation, comprehensive policies, economic incentives, and educational initiatives, the Metro Vancouver region can achieve a sustainable and circular wood waste management system. This strategy aligns with the circular economy's goals of reducing waste, conserving resources, and fostering economic opportunities. The recommendations in this report could guide the NZWC in promoting effective and sustainable wood waste solutions, ultimately enhancing the region's environmental and economic well-being.

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Glossary

Building Information Modelling (BIM): The virtual representation of the physical and functional characteristics of a building from inception onward. It serves as a shared information repository for collaboration throughout a facility's life cycle.

Circular Economy: An economic system aimed at minimizing waste and making the most of resources. This involves reusing, repairing, refurbishing, and recycling existing materials and products to extend the life of materials and create closed-loop systems, reducing the need for new resources and carbon used in material production and construction processes.

Construction, Renovation, and Demolition (CRD): Activities related to the construction of new buildings, the renovation of existing structures, and the demolition of buildings or other structures.

Design for Disassembly (DfD): A building design process that allows for the easy recovery of products, parts, and materials when a building is disassembled or renovated. The process is intended to maximize economic value and minimize environmental impacts through reuse, repair, remanufacture, and recycling.

Deconstruction: The process of dismantling a building or structure in a way that allows materials to be reused or recycled.

Demolition: The complete or partial destruction of buildings or structures without prioritizing resource recovery or considering the environmental impacts.

Embodied Carbon: The total greenhouse gas emissions associated with a material or product's life cycle. It includes energy-related emissions, manufacturing emissions, and construction emissions. Considering embodied carbon helps in making informed decisions about materials and products.

Extended Producer Responsibility (EPR): A policy approach that shifts the responsibility for managing end-of-life products from municipalities to producers.

Linear Economy: A production and consumption model characterized by a one-way flow of resources: extracting raw materials, manufacturing products, and disposing of them as waste after use.

Material Passport: A digital record of a product's materials and components, used to facilitate reuse and recycling.

Material Parsimony: Using fewer types of materials in product design to simplify recycling and waste management. This approach enhances recyclability, reduces environmental impact, and conserves resources by minimizing material diversity.

Medium Density Fiberboard (MDF): A type of engineered wood product made by breaking down hardwood or softwood residuals into wood fibres, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure.

Modular Construction: A construction method that involves building individual modules off-site and then assembling them on-site.

Post-Consumer CRD Wood: This refers to used/discarded materials generated from CRD activities. The focus is on managing and recycling these materials to reduce landfill disposal and promote circular economy practices in the Metro Vancouver region.

Prefabrication: The process of manufacturing building components off-site and then assembling them on-site.

Recycling: The process of converting waste materials into new products.

Salvage: The recovery of resources that may otherwise be destined for the landfill.

Stakeholders: Individuals or groups with an interest or concern in the CRD wood waste management sector. This includes CRD contractors, policy-makers, municipal councils, founders and CEOs of recycling and deconstruction firms, advocates for sustainable building practices, and academic researchers.

Sorting: The process of separating different types of waste materials from each other to reuse, upcycle, or recycle resources.

Upcycling: The process of converting waste materials into new products of higher value.

Voluntary Organic Compounds (VOCs): Organic chemicals that are emitted by a wide array of products including paints, cleaning supplies, pesticides, and building materials. They can produce adverse health effects and contribute to indoor air pollution.

Wasteful Practices: Practices that cause the unnecessary disposal of materials that could be reused or recycled.

Waste-to-Energy (WtE): A process that converts municipal solid waste into usable energy forms such as electricity, heat, or fuel through methods like incineration, gasification, pyrolysis, or anaerobic digestion.

Rethinking Our Language

Terminology plays a crucial role in shaping industry practices and perceptions. The term "waste" implies disposability and lack of value, which can hinder efforts to promote circular practices. Experts consistently emphasize the need to redefine these materials, recognizing their potential for reuse and repurposing. By creating a shared language that reframes "waste" as valuable resources, we can foster a culture of sustainability and resource efficiency.

Several industry experts highlighted in interviews the importance of language, noting that terminology directly influences how materials are treated and valued. Labelling materials as "waste" diminishes their perceived value and potential for reuse. Shifting the language we use can fundamentally alter how people view and handle these post-consumer CRD materials, encouraging practices that extend their lifecycle.

By rethinking our language and conceptualizing post-consumer materials as valuable resources rather than waste, we can drive significant improvements in resource management, waste reduction, and sustainability. This approach aligns with the goals of promoting circular economy principles and creating economic opportunities within the CRD sector.

List of Tables and Figures

Introduction

The National Zero Waste Council (NZWC) Construction, Renovation, and Demolition (CRD) Working Group engaged the Circular Roots Collective (CRC), a BCIT Sustainable Business student consulting team, to tackle the pressing issue of wood waste in the Metro Vancouver region. Wood waste from CRD activities constitutes almost half of the landfill material, with only a minimal fraction being effectively reused or recycled. This report aims to identify circular solutions to mitigate wood waste disposal and unlock economic opportunities within the framework of a circular economy.

The NZWC, an initiative of the Metro Vancouver region, is leading Canada's transition to a circular economy by uniting governments, businesses, and NGOs to prevent waste and maximize economic benefits. Their mission is to make Canada a zero-waste nation by reducing waste in the design, production, and use of goods, highlighting the economic, social, and environmental benefits. The Council's Construction & Demolition initiative focuses on wood waste recovery, seeking innovative solutions to divert it from landfills.

Emphasizing circular economy principles, this report highlights resource recovery, reuse, recycling, and design strategies to reduce wood waste from a building's inception. It also identifies existing and emerging technologies, best practices, and policy frameworks that extend the lifecycle of wood in the CRD industry.

The report starts with a background on the environmental and economic impacts of wood waste and circular economy principles, followed by a detailed methodology for research transparency. The results section highlights key findings, trends, challenges, and opportunities in circular wood waste utilization. A discussion analyzes these findings' implications for policy, industry, and the environment. The conclusion and recommendations summarize the key insights and provide practical steps for the NZWC to promote circular solutions to wood waste in the Metro Vancouver region.

By examining successful practices globally and addressing specific barriers in the context of the Lower Mainland of British Columbia, this report aims to guide the region towards a more sustainable and economically beneficial approach to circular wood practices. The recommendations provided will support the NZWC's mission to reduce waste, conserve resources, and create innovative solutions that foster a sustainable future.

Background

The NZWC, an initiative of the Metro Vancouver region, leads Canada's transition to a circular economy by uniting various stakeholders to promote waste prevention and circular practices. Aiming for a zero-waste Canada for current and future generations, the organization collaborates with businesses, governments, and communities both nationally and internationally. Their mission is to prevent and reduce waste throughout the design, production, and use of goods, highlighting the economic, social, and environmental benefits of resource conservation.

The National Zero Waste Council's Construction, Renovation and Demolition (CRD) working group recognizes the immense value of wood waste currently destined for landfills. Wood waste recovery is a key component of the Council's mission, and they are actively exploring emerging and innovative solutions to address this challenge.

Within the geographical boundaries of the Metro Vancouver region, one-third of the waste sent to landfills originates from CRD activities, and wood waste alone comprises nearly half of this waste category at 48% by weight.[1] Vancouver waste from the CRD sector is managed primarily at the Vancouver Landfill and Recycling Depot (VLF) and Ecowaste Industries Ltd., a landfill located in Richmond, BC that specifically manages construction, demolition, and excavation materials.

The wood waste composition results for VLF and Ecowaste are interpreted in the following sections as weighted average tonnes and percentages.

Table 1 Represents the total wood waste disposed in 2021 at VLF and Ecowaste. Metrics received by a 2022 Construction and Demolition Waste Composition Study for Metro Vancouver, by Dillon Consulting Limited. The annual tonnes at each landfill were provided by Metro Vancouver when used to calculate the estimated annual wood waste generated.

Table 1: Total Estimated Wood Waste Disposal (2021)

Location	Estimated Annual Weight of C&D Waste (tonnes)	Total Wood % by Volume	Total Wood % by Weight	Estimated Annual Weight of Wood Waste (tonnes)
VLF	118,046	63%	65%	76,395
Ecowaste	178,504	38%	42%	75,807

Wood constituted the largest estimated portion of construction and demolition waste by volume and weight at landfills. At VLF, primary categories based on weight included stained and treated dimensional lumber (32%), plywood (21%), particleboard (11%), fiberboard (10%), clean wood (9%), and salvageable wood fixtures (2%). In the case of Ecowaste, categories comprised largely of salvageable wood fixtures (20%), plywood

[1] Metro Vancouver (2024). Construction and Demolition Waste Reduction Toolkit . Retrieved from https://metrovancouver.org/services/solid-waste/Pages/construction-demolition-waste-reduction-toolkit.aspx

(17%), stained and treated dimensional lumber (15%), clean wood(12%), particleboard (11%), and fiberboard (9%).[2]

Figure 1 is a flow diagram that visualizes the proportion of primary categories, displaying the material flow of wood waste composites within VLF and Ecowaste. Regional average results were interpreted based on weighting the C&D tonnages from VLF and Ecowaste.

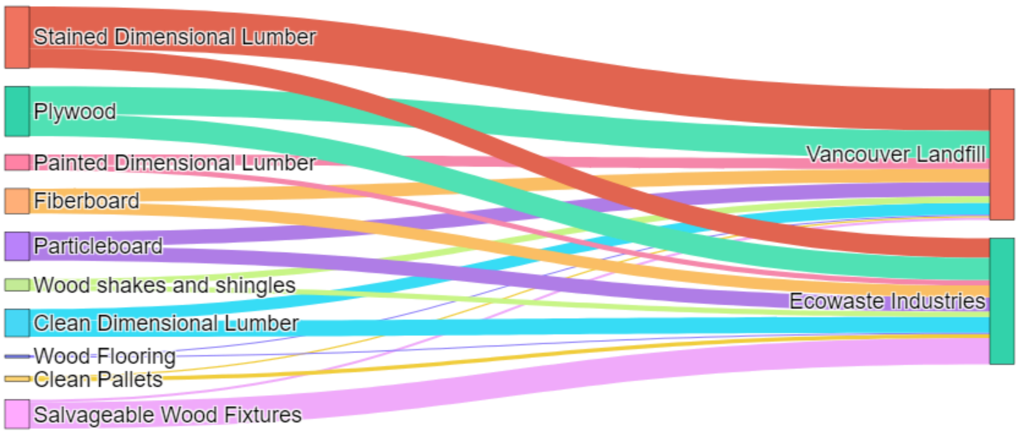

Figure 1. Wood Waste Composition at Vancouver Landfill and Ecowaste

A circular built environment focuses on three core elements: the adaptive reuse of existing buildings, the adaptive design of new buildings, and the reuse of materials.[3] This approach requires architects, builders, and deconstruction companies to select materials and processes that optimize operational efficiency and facilitate material recovery. Currently, the industry predominantly follows linear practices for time and cost efficiency. However, transitioning to circular practices can significantly reduce carbon emissions, enhance biodiversity, and maximize the potential of wood resources.[4]

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[2] Dillon Consulting Limited. (2023, October). 2022 Construction & Demolition Waste Composition Study . Retrieved from https://metrovancouver.org/services/solid-waste/Documents/construction-demolition-waste-composition-study-2022.pdf

[3] Bansal, T., et al. (2024). The Circular Built Environment in Canada: A Strategic Framework for Future Action . SCIUS Advisory & Circular Economy Leadership Canada (CELC), Innovation North. Retrieved from https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-The-Circular-Built-Environment-in-Canada-A-Strategic-Framework-for-Future-Action.pdf

[4] Bowyer, J., et al. (2023). Circularity Concepts in Wood Construction . Geneva Timber and Forest Study Paper 95, Geneva. Retrieved from https://unece.org/sites/default/files/2023-05/ECE_TIM_DP95E_web.pdf

Methodology

A combination of desktop research and expert interviews was employed to gain a comprehensive understanding of the current statistics, initiatives, challenges, recent research, circular solutions, and product innovations of post-consumer wood within the CRD sector.

Desktop Research

The desktop research drew from a wide array of sources to ensure credibility and comprehensiveness: in-depth literature reviews on circular economy principles and wood waste management, data on regional wood waste generation and disposal patterns, and industry case studies on innovations and best practices in wood waste utilization.

The team undertook desktop research focused on the following questions mentioned below (see Appendix I):

- What are the current wood waste recycling practices and challenges facing the CRD industry?
- What are the successful businesses, technologies, and circular solutions globally that enhance wood waste reuse and recycling?
- How has using recycled wood in product innovation improved the recycling process and what effects does it have on the quality, durability, and market acceptance of the products?

Expert Interviews

Interviews focused on gathering insights from industry stakeholders, experts, and representatives of environmental organizations. Sixteen interviewees were selected based on input from clients, the faculty advisor, and a gap analysis from secondary research.

The interviewees have all made significant contributions in areas such as CRD, circular economy entrepreneurship, wood recycling, deconstruction practices, and wood waste recycling research. Ethical considerations, including informed consent, were paramount in the research and sought from each interviewee (see Appendix II).

Interview questions addressed gaps identified during the desktop research stage and compiled more in-depth insights on key topics. Interview questions were centred around effective sorting technologies and challenges in post-consumer CRD wood separation, integration of Design for Deconstruction principles in construction, and assessing the current market and recycling opportunities for MDF (see Appendix III).

The team used a systematic, inductive approach to organize interview data, starting with a list of tailored codes. Team members conducted interviews with customized questions, adding new codes as needed for emerging insights. To ensure reliability, multiple team members coded each interview, and regular meetings were held to discuss and consolidate findings, ensuring thorough analysis.

Results

The results integrate findings from desktop research and expert interviews to present a comprehensive overview of the CRD industry's current post-consumer wood practices, an analysis of stakeholder challenges to embracing circular practices, and successful circular innovations in wood management and waste prevention.

The high disposal rate of post-consumer wood from CRD projects to Metro Vancouver's landfill, accompanied by limited recycling and reuse infrastructure, poses significant barriers to the widespread adoption of circular solutions. The region's economic environment favours disposal of wood over reuse, and regulatory frameworks vary across jurisdictions, hindering sector-wide progress and stakeholder engagement. Nevertheless, an increasing interest in sustainable building practices and circular economy principles indicates a shift towards more ecologically resilient approaches.

The Existing CRD Landscape in the Metro Vancouver Region

The CRD landscape in the Metro Vancouver region is characterized by substantial wood waste generation, underscoring the necessity for improved management practices. The most common methods of post-consumer wood management include mechanical processing like grinding or chipping to create mulch, biomass fuel, or materials for engineered wood products.[5] These processes do not retain the regenerative value of wood. Vancouver's Zero Waste initiatives and recycling mandates aim to enhance circular waste management. Yet, current practices face obstacles in more fully extending the life cycle of deconstructed materials, highlighting the need for innovative approaches.[6]

Key Findings and Identified Gaps

Global companies such as Steinert GmbH and TOMRA Recycling utilize long X-ray transmission sorters, and deep-learning X-ray machines respectively to achieve high precision in sorting post-consumer wood. This innovative technology enables the

[5] Dillon Consulting Limited, 2022 Construction & Demolition Waste Composition Study (2023)
[6] Nielsen-Roine, K. (2023, May 4). Use It Up, Wear It Out: Valorizing Wood Waste in Vancouver BC [G]. doi:http://dx.doi.org/10.14288/1.0432055

identification and separation of different wood materials with unparalleled accuracy, thereby optimizing recycling processes.[7] [8]

Recovered wood is increasingly transformed into high-quality products like furniture, art, board games, and architectural elements, promoting sustainability through biocompatible cycles.[9] These consumer-ready items illustrate the aesthetic and functional integration of recycled wood in everyday life.

Design for Disassembly (DfD) is a key circular innovation mentioned by many interviewees. It emphasizes designing buildings for easy disassembly at the end of their lifecycle, facilitating the reuse or recycling of components. Local examples such as Nexii and global leaders like Plant Prefab in California lead in sustainable construction with prefabricated units, emphasizing minimal environmental impact through the use of wood in modular construction, a renewable and sustainably sourced material.[10]

The research revealed several gaps in post-consumer wood management practices, such as insufficient recycling infrastructure, circular recycling initiatives, standardized policies, and limited financial incentives in the regional district of Metro Vancouver.

The Emerging Circular CRD Landscape

This section presents key findings from expert interviews, highlighting the most emphasized themes and solutions to the challenges faced in managing CRD wood. Respondents noted successes such as on-site recycling sorting stations and prefabrication of timber structures, alongside innovations like artificial intelligence (AI) for removing metal fasteners. The importance of digital information-gathering systems was also underscored.

An overview of barriers to circular practices is provided, along with success factors, and circular innovations that show promising potential. These advancements, supported by financial incentives and regulatory frameworks, can aid the sustainable recovery of wood resources.

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[7] Wood - TOMRA - Material sorting - waste recycling. (2024). TOMRA . Retrieved from https://www.tomra.com/en/waste-metal-recycling/applications/waste-recycling/wood

[8] STEINERT GmbH. (n.d.). Sorting & recycling of valuable materials from construction and demolition waste. STEINERT . Retrieved from https://steinertglobal.com/us/waste-recycling/construction-and-demolition-waste/

[9] Claret, C., & Lemus, J. (2019, May 17). Upcycling Wood: Disused Materials Transformed Into Valuable And Useful Objects. ArchDaily . Retrieved February 15, 2024, from https://www.archdaily.com/916482/upcycling-wood-disused-materials-transformed-into-valuable-and-useful-objects?ad_source=search&ad_medium=projects_tab&ad_source=search&ad_medium=search_result_all

[10] Plant Prefab. (2024). Retrieved from https://www.plantprefab.com/

Key Barriers to Circular Practices for CRD Wood Recovery

1. **Challenging Mindsets Toward Waste**
   - Industry leaders emphasize the need to educate stakeholders about wood circularity and the circular economy.[11] [12] [13] [14] [15]
   - The negative impact of terms like "waste" perpetuates limiting perceptions towards resource reuse.[16]
   - Education is pivotal for shifting attitudes and behaviours toward sustainable practices that prioritize reusing and recycling wood materials.
2. **Regulatory Constraints**
   - The absence of unified policies and consistent practices, coupled with inconsistent demand for material reuse, hinders sustainable wood resource management.[17]
   - The multifamily housing sector faces stringent building code requirements and liability concerns, complicating prefab adoption and scaling efforts.[18]
   - Experts highlight challenges in this area such as regulatory disparities, labour shortages, and logistical complexities that require collaborative efforts from diverse stakeholders to develop and implement effective resource recovery strategies.[19]
   - Limited municipal facilities hinder efficient recycling. Noting cost barriers and political motivations impeding widespread adoption. [20]
   - Despite existing policies, lack of enforcement and follow-through often leads to non-compliance, resulting in improper wood waste recycling.[21]
3. **Wasteful Practices**
   - Modern construction with nail guns uses more nails per board than older methods, resulting in increased waste and making reuse more challenging.[22]
   - Economic disincentives, such as the low cost of raw wood compared to high labour costs for recovering used wood, deter salvaging and reuse.
   - Industry insiders note inefficiencies in sorting and disposal methods,

[11] Interview with Adrian Lopera-Valle, Circular Innovation Lead at Light House, conducted on April 19, 2024.
[12] Interview with Matthäus Hermann, Co-founder at Urbanjacks, conducted on April 8,2024.
[13] Interview with Erick Serpas Ventura, Founder of Vema Deconstruction, conducted on March 19, 2024.
[14] Interview with Chris Arkell, Co-Founder of Sea to Sky Removal, conducted on May 1, 2024.
[15] Interview with Peter Moonen, National Sustainability Manager at The Canadian Wood Council, conducted on March 15, 2024.
[16] Interview with Sheila Molloy, Executive Director of Coast Waste Management Association, conducted on April 10, 2024.
[17] Dalo, Program Manager at the Carbon Leadership Forum BC, April 11, 2024.
[18] Interview with Helen Goodland, Principal and Head of Research and Innovations at Scius Advisory, conducted on March 25, 2024.
[19] Molloy, Executive Director of Coast Waste Management Association, April 10, 2024.
[20] Arkell, Co-Founder of Sea to Sky Removal, May 1, 2024.
[21] Interview with James Donaldson, CEO of Canadian Wood Waste Recycling Business Group, conducted on March 21, 2024
[22] Interview with Kaia Nielsen-Roine, PhD: University of British Columbia, conducted on March 18, 2024.

reluctance to adopt sustainable technologies to enhance sorting efficiency, and insufficient education on material reuse.

4. **Inadequate Economic Incentives**
   - Experts underscore inadequate financial motivations for adopting sustainable resource management practices.[23] [24]
   - This lack of support complicates businesses' ability to justify initial investments in circular innovations, exacerbated by regulatory inconsistencies and unclear policies.
   - Current low tipping fees on landfilling certain materials dissuades CRD waste diversion.[25]
5. **Sorting Obstacles**
   - Logistical hurdles, construction project schedules, and a shortage of trained staff impede efficient wood sorting practices.[26]
   - North American facilities currently need more infrastructure for effective source separation, which hinders effective wood material management.[27]
   - Deconstructing buildings, especially older homes, can be hazardous for workers, due to dealing with toxic materials like asbestos and the labour-intensive nature of stripping down a structure.[28]
6. **Technological Adoption for Source Separation**
   - Scaling advanced sorting machines and digital tools such as AI for metal fastener removal requires significant upfront investments, which can pose challenges for smaller businesses to adopt these innovations.[29] [30]
   - Adherence to traditional methods of CRD waste management also hinders the adoption of waste management technologies.[31] [32]

Success Factors to Advance Circular Wood Innovation

This section presents key insights gained from analyzing the research, offering practical approaches to enhance circularity within the CRD sector.

Industry leaders have emphasized successful strategies such as on-site recycling stations, bolstering entrepreneurial initiatives, and prefabrication-building techniques. Moreover, advanced technologies like AI for fastener removal and digital project delivery contribute to improved material recovery. These advancements collectively promote a more sustainable CRD industry.

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[23] Dalo, Program Manager at the Carbon Leadership Forum BC, April 11, 2024.
[24] Molloy, Executive Director of Coast Waste Management Association, April 10, 2024.
[25] Lopera-Valle, Circular Innovation Lead at Light House, April 19, 2024.
[26] Interview with James Donaldson, CEO of the Canadian Wood Waste Recycling Business Group, conducted on March 21, 2024.
[27] Coast Waste Management Association: Leaping Into Actions to Reuse & Recycle Construction Wood Waste [Webinar], February 29, 2024
[28] Ventura, Founder of Vema Deconstruction, March 19, 2024.
[29] Hermann, Co-founder at Urbanjacks, April 8,2024.
[30] Ventura, Founder of Vema Deconstruction, March 19, 2024.
[31] Lopera-Valle, Circular Innovation Lead at Light House, April 19, 2024
[32] Dalo, Program Manager at the Carbon Leadership Forum BC, April 11, 2024

1. **Implementation of On-Site Systems**
    - Implementing recycling stations and multiple bin systems have proven successful results in adopting circular practices. These approaches streamline waste separation practices and encourage responsible behaviours of material management.[33] For example, businesses like Urban Machine and Urbanjacks have clear specification requirements on the wood they collect from their customers.[34]
    - Successful on-site sorting businesses provide customers with the necessary training for efficient source separation. Sea to Sky Removal educates customers on waste separation benefits, encouraging participation to streamline waste handling and reduce costs.[35]
2. **Community and Entrepreneurial Efforts**
    - Community involvement and entrepreneurial initiatives drive innovation in waste management. For example, collaborations such as community-led recycling programs and entrepreneurial ventures introduce new solutions to enhance recycling rates and reduce waste.[36]
    - Initiatives like resource libraries, maker spaces, and collaborative events are beneficial to advancing reuse practices and innovation.[37]
    - Collaboration between all industry players and public sector entities is essential to drive innovation for effective recycling and recovery processes and circular building practices.[38] [39]
3. **Prefabrication and Modular Construction Techniques**
    - Prefabrication and modular construction methods reduce waste and provide solutions to waste created during the design phase of projects. These techniques ensure higher material efficiency and minimize waste creation by manufacturing building components offsite in controlled environments, in comparison to traditional building practices.[40] These approaches offer potential cost savings in labour and materials over the lifecycle and eventual disassembly of buildings.[41]
    - Prefabrication of timber structures is a prominent solution. This method optimizes material use by allowing for precise cutting and reuse of offcuts, thus reducing waste during construction.[42]
4. **Technological Integration**
    - Integrating AI for accurate metal fastener identification and removal, wood sorting machinery, and the digitalization of project information systems to

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[33] Arkell, Co-Founder of Sea to Sky Removal, May 1, 2024.
[34] Wisnefski, Marketing Manager at Urban Machine, March 25, 2024.
[35] Arkell, Co-Founder of Sea to Sky Removal, May 1, 2024.
[36] Molloy, Executive Director of Coast Waste Management Association, April 10, 2024.
[37] Dalo, Program Manager at the Carbon Leadership Forum BC, April 11, 2024
[38] Moonen, National Sustainability Manager at The Canadian Wood Council, March 15, 2024.
[39] Lopera-Valle, Circular Innovation Lead at Light House, April 19, 2024.
[40] Goodland, Principal and Head of Research and Innovations at Scius Advisory, March 25, 2024.
[41] Nielsen-Roine, PhD: University of British Columbia, March 18, 2024.
[42] Goodland, Principal and Head of Research and Innovations at Scius Advisory, conducted on March 25, 2024.

aid after-life disassembly, is key to facilitating efficient recycling and reuse, thus, maximizing resource recovery.
    - Technologies for deconstructing buildings, such as drones and systems like LiDAR (Light Detection and Ranging Laser) used to measure and determine a building's salvageable content, streamline CRD processes and raise material recovery rates.[43]
5. **Adaptive Reuse**
    - Industry professionals emphasize adaptive building reuse, repurposing existing materials and structures rather than demolishing them, reducing waste generation. This approach preserves embodied carbon and lowers environmental impact compared to new construction.[44]
    - Reusing materials from end-of-life buildings in new projects creates markets for materials salvage from deconstructed buildings while conserving resources and reducing waste.
6. **Comprehensive Policies and Mandates**
    - Experts emphasize the need for supportive regulations to incentivize and mandate deconstruction practices and support design for disassembly in new buildings.
    - Incentives and Mandates: Promoting deconstruction and developing markets for reclaimed materials are crucial. Cities can support these initiatives by providing grants and facilitating connections between construction companies and material markets.[45]
    - Design for Deconstruction: Policies like the City of London's Circularity Act mandate consideration of material circularity and end-of-life planning for new constructions and major renovations.[46]
    - Progressive regulations in Vancouver promote CRD wood recovery viability. Extending such regulations across all of the Metro Vancouver regional municipalities is crucial for scaling efforts. [47]

Key Innovations in Circular Practices

The following findings spotlight the most emphasized and promising solutions identified in the research for managing CRD wood. They examine strategies and challenges related to innovation in the CRD industry, encompassing aspects such as designing for deconstruction, sorting mechanisms, and technological innovations.

[43] Ventura, Founder of Vema Deconstruction, March 19, 2024.
[44] Interview with Zosia Brown, Vice President of Sustainability at Nexii Building Solutions, conducted on April 29, 2024.
[45] Ventura, Founder of Vema Deconstruction, March 19, 2024.
[46] Brown, Vice President of Sustainability at Nexii Building Solutions, April 29, 2024.
[47] Wisnefski, Marketing Manager at Urban Machine, March 25, 2024.

Source Separation

Implementing effective sorting mechanisms is imperative to making meaningful improvements in managing post-consumer CRD wood. Innovations like material passports and automated sorting technologies can improve the efficiency and accuracy of wood sorting. Expert interviewees championed these innovations because they prevent waste upstream and enhance the downstream recyclability of materials.

Key points highlighted include:

1. **Using Higher Quality Materials**
   - Jose Matas, Global Director of the Wood Segment at TOMRA Recycling in Spain, underlines the value of source separation for maintaining high-quality recyclable materials. Contamination from mixed debris diminishes wood resource recyclability and value.
2. **Efficiency in Recycling Processes**:
   - Chris Arkell, Sea to Sky Removal's Co-founder, stated that separating wood waste at the source simplifies our processes. It makes sorting and processing much more efficient and cost-effective, allowing us to recover more usable materials.
   - Interviews with industry experts highlighted the implementation of multiple bin systems to enhance onsite sorting practices, optimizing efficiency.
   - Innovations such as AI for removing fasteners further streamline reusing processes and improve operational efficiency. [48]
3. **Regulatory Compliance and Incentives**
   - Mandating regulatory compliance and government-based financial incentives play a pivotal role in driving sustainable waste management practices. Erick Serpas Ventura of Vema Deconstruction highlights that adherence to source separation guidelines not only ensures compliance with local regulations but also qualifies them for financial incentives, motivating rigorous separation practices.
   - Matthäus Hermann of Urbanjacks underscores that high disposal costs incentivize effective sorting and recycling of CRD, illustrating how economic factors can drive sustainability efforts.
   - Sheila Molloy, Executive Director of Coast Waste Management Association, emphasizes the importance of regulatory frameworks in standardizing practices and promoting sustainability, despite challenges like labour scarcity and regulatory inconsistencies noted by Akrell and Serpas Ventura, respectively.
   - Addressing these barriers requires comprehensive strategies that enhance operational efficiency while fostering supportive financial and regulatory environments for sustainable waste management practices.

[48] Wisnefski, Marketing Manager at Urban Machine, March 25, 2024.

Design for Disassembly

Design for disassembly and deconstruction emerged as a pivotal forward-facing strategy for enhancing the recyclability and reuse of wood products. Key insights from the interviews include:

1. **Facilitation of Material Recovery**
    - Designing products with end-of-life deconstruction in mind simplifies the process of recovering and reusing wood components, ensuring their preservation and minimizing waste generation.
    - This approach supports circular economy principles by extending the life cycle of materials and reducing environmental impact. Interviewees highlighted successful examples where companies, like Vema Deconstruction and Unbuilders, have implemented DfD strategies, demonstrating improved resource efficiency and sustainability in their operations.
2. **Market Demand**
    - Chris Arkell of Sea to Sky Removal emphasizes that there is an increasing market demand for products designed for disassembly and deconstruction. This highlights how companies that embrace DfD practices gain a competitive advantage by appealing to environmentally conscious consumers.
    - This trend reflects a broader shift towards sustainable building practices where products are not only functional but also designed for ease of reuse and recycling, thereby reducing environmental impact.
    - Companies leading in this area demonstrate a commitment to sustainability and innovation, aligning with consumer expectations for environmentally responsible products and services.
3. **Prefabrication**
    - Strategies such as prefabrication, modular construction, and material passports are gaining focus in the CRD industry as they facilitate material recovery.
    - This approach was highlighted by Zosia Brown, Vice-President of Sustainability at Nexii Building Solutions, as essential for preventing waste upstream and promoting sustainability in construction practices.
4. **Technological Advancements**
    - Technologies like BIM, 3D scanning, and AI play a crucial role in enhancing resource management by improving efficiency, reducing errors, and enabling better tracking and management of materials in construction projects.
    - Material Passports quantify materials and assign a value at the end of their life, facilitating easier identification and separation of materials for reuse or recycling during deconstruction. Experts Helen Goodland, Principal and Head of Research and Innovations at Scius Advisory, and

Stephanie Dalo, Program Manager at the Carbon Leadership Forum BC, cite these innovations as essential for advancing waste reduction efforts through improved project planning and material management.

Challenges with Recycling MDF

Advancements in recycling technologies, such as machine learning and automation for MDF recycling, contribute to creating a closed loop for this material which is challenging to recycle efficiently (see Appendix IV). However, in the context of the Metro Vancouver region, recycling MDF poses substantial challenges, as highlighted by respondents.

Key issues identified include:

1. **Material Composition**:
    - The challenge of recycling MDF is due to its composition of wood fibres bonded with resin and adhesives, which complicates separation and often results in lower-quality recycled material.[49] [50] [51] [52]
    - MDF is typically difficult to recycle because it is often clad with a plastic, melamine, or resin-based product, making it contaminated.[53]
    - MDF presents an obstacle due to its fiber composition, which complicates its recycling process when mixed with other wood materials. There is ongoing research and efforts within the industry to develop methods to recycle MDF effectively.[54]
2. **Market and Infrastructure Challenges in North America**:
    - The lack of infrastructure and technology specifically designed for MDF recycling, leading to its frequent disposal in landfills. There are no particleboard manufacturing facilities in operation in BC.
    - Local markets struggle to absorb waste streams like MDF due to contamination and lack of standardized recycling processes, highlighting the inefficiencies in current waste management practices.[55]
    - The lack of a robust recycling infrastructure and limited demand for recycled materials pose significant challenges. This contrasts with regions like Europe where such infrastructure and demand are more established.[56]

Recycling or upcycling MDF in the Metro Vancouver region is currently unfeasible due to the lack of readily adaptable technology, regional particleboard manufacturing facilities,

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[49] Moonen, National Sustainability Manager at The Canadian Wood Council, March 15, 2024.
[50] Hermann, Co-founder at Urbanjacks, April 8, 2024.
[51] Nielsen-Roine, PhD: University of British Columbia, March 18, 2024.
[52] Matas, Global Director - Wood Segment at TOMRA Recycling, May 17, 2024.
[53] Moonen, National Sustainability Manager at The Canadian Wood Council, March 15, 2024.
[54] Matas, Global Director - Wood Segment at TOMRA Recycling, May 17, 2024.
[55] Goodland, Principal and Head of Research and Innovations at Scius Advisory, conducted on March 25, 2024.
[56] Matas, Global Director - Wood Segment at TOMRA Recycling, May 17, 2024.

and economic incentives. Additionally, the resins and adhesives in MDF severely complicate recycling, hindering viable circular solutions for this wood waste.

Discussion

Transforming Wood Recovery in Metro Vancouver

The CRD landscape in the Metro Vancouver region is an ever-changing space, where the hum of progress often overshadows a critical issue: the substantial amount of wood discarded as waste. These piles of unused wood represent not only environmental concerns but also lost economic opportunities.

However, a possible shift is underway, driven by growing sustainability mindsets and the circular economy. This discussion explores the innovative strategies and collaborative efforts transforming how post-consumer wood is managed, turning potential waste into valuable resources and paving the way for a more resourceful future.

Setting the Foundation for Successful CRD Wood Recovery

At the heart of this transformation is intentional design and source separation. Separating materials at their origin ensures higher-quality recyclables by preventing contamination. By separating post-consumer wood from the start, the quality and value of recyclable materials improve. Intentional design addresses the root cause of waste and extends the life of buildings and their materials.

Facing the Challenges

Policies and regulations significantly influence the adoption and integration of advanced technologies in waste management. Supportive policies can foster innovation in sustainable demolition and the adoption of technologies in waste processing. However, not all wood waste is easy to recycle. For instance, recycling MDF is particularly challenging due to its complex composition, the lack of specialized recycling infrastructure, and economic barriers that discourage its recycling.

Time and space constraints on construction sites often hinder effective sorting and storage of materials. Assigning sustainability tasks to personnel without the necessary skills or commitment leads to inefficiencies. Additionally, limited perceptions associated with terms like "waste" complicate resource management efforts.

Building with the End in Mind, A Call to Action

Designing products with end-of-life deconstruction in mind allows for easier recovery of wood components, preserving the integrity of materials for reuse. This approach not only facilitates material recovery but also aligns with market demands for sustainable practices. While the initial investment in design for disassembly might be higher, the long-term sustainability benefits are clear. Reduced overall waste management costs and significantly lessened environmental impact highlight the advantages of this strategy.

The broader CRD landscape in the Metro Vancouver region underscores the urgency of these innovations. The city generates high levels of wood waste, but recycling and reuse infrastructure is limited. Economic incentives currently favour disposal over reuse, and regulatory frameworks vary across jurisdictions. Despite these challenges, there is a growing interest in sustainable building practices and circular economy principles.

Comparing Past and Present for Future Growth

Comparing the age of buildings in the Metro Vancouver region to the history of forests in the Pacific Northwest illustrates a stark contrast in timelines and human impact. The relatively young age of buildings in the Metro Vancouver region reflects rapid urban development over the past century. In contrast, the history of forests in the Pacific Northwest spans millennia, shaped by natural processes and Indigenous stewardship long before urbanization. Balancing development with the preservation of these landscapes ensures our future is informed by our past.

Embracing a New Vision for the Future

Innovative practices and technologies play a crucial role in this transformation. Effective sorting mechanisms, designing for disassembly, and technological advancements such as BIM, 3D scanning, and AI can all help drive this change. These innovations improve efficiency, reduce errors, and facilitate better tracking and management of materials.

Envisioning a sustainable future involves cohesive efforts from policymakers, industry leaders, builders, workers, and the community at large. By addressing challenges and leveraging proven success factors, sustainable construction can transform waste into wealth and nurture a resilient urban environment. This sets the stage for the following recommendations on adopting circular CRD wood sorting systems and design for disassembly principles.

Recommendations

The following section outlines recommendations to promote the widespread adoption of two key circular innovations with significant potential to reduce wood waste sent to landfills: design for disassembly (DfD) and enhanced source separation of wood waste. The recommendations are categorized into two groups: one targeting policymakers and the other aimed at influencing CRD business practices.

Policy encompasses a broad spectrum of actions available to governments at all levels, including regulations, education, economic incentives, and building codes, which can either enable specific activities or unintentionally create barriers. Comprehensive and standardized policies are essential to effectively shape behaviours and outcomes within the CRD sector.

The NZWC CRD Working Group could foster the adoption of circular business models by offering guidance, facilitating collaborations, and advocating for the reuse, recycling, and integration of DfD principles. By addressing existing barriers and promoting best practices, the NZWC CRD Working Group could play a pivotal role in driving the essential innovation and growth required in this sector.

Wood Sorting Systems Designed for Circularity

Source separation plays a critical role in maximizing wood recovery and reuse within the CRD sector. Simplifying and incentivizing wood sorting at its source requires clearly outlining who is responsible for sorting and how it should be done at every stage of the lifecycle of CRD wood and throughout the sector's supply chain. This ensures accurate sorting, thereby enhancing recycling efficiency.

Education and training are key in equipping stakeholders with the necessary knowledge and skills for effective separation techniques. Advanced sorting technologies further streamline this process by facilitating the identification and recovery of reusable materials. Supporting specialized businesses in deconstruction and material recovery, such as Urbanjacks, also promotes sustainable practices within the industry.

The predominance of demolition methods poses a barrier to salvage, reuse, and upcycling practices. However, redefining these methods as deconstruction and disassembly can catalyze market change. This shift not only supports the emergence of new industries focused on sustainability but also encourages innovative business models that prioritize the circular economy.

1. Source Separation Businesses Recommendations

(1.1) Adopt Advanced Sorting Technologies

- Utilize multiple-bin solutions and detailed waste sorting systems to enhance on-site separation processes.

One regional example is Sea to Sky Removal that provides construction sites with designated recycling areas and bins, helping contractors reduce landfill costs and recover CRD materials like wood.

Figure 2. [Image]() of On-site Recycling Station Designed by Sea to Sky Removal

- Implement advanced sorting mechanisms, such as AI-driven systems, to improve the efficiency and accuracy of wood sorting.
    - Example: Vema Deconstruction, a company specializing in sustainable construction practices, has signed a Letter of Intent (LOI) to collaborate with Urban Machine, a leader in removing metal fasteners from reclaimed wood. This partnership aims to enhance Vema's wood reclamation process by leveraging Urban Machine's cutting-edge technology.[57]
        - Vema Deconstruction's technology includes robots that dismantle structures and segregate materials, high-efficiency saw and shredders to convert reclaimed wood into reusable materials, digital inventory systems to track and manage reclaimed materials, and a sustainability metrics system that tracks environmental performance indicators.[58]
        - Urban Machine's technology uses AI machines to identify different types of wood and separate them based on quality and usability. AI algorithms are employed to detect contaminants such as nails, screws, and other metal fasteners to ensure safety and quality of reused materials. Robotics are used to automate the removal of contaminants from wood including tasks such as pulling out nails and screws.[59]

(1.2) Stimulate Market Demand: Push for Sorting Innovation and Infrastructure

- Creating strong market demand for upcycled post-consumer wood from the CRD sector is essential for driving circular innovation. The NZWC could encourage the use of recycled wood in non-structural public projects, like

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[57] Wisnefski, J. (2024, April 17). Vema Deconstruction and Urban Machine Join Forces. Urban Machine. https://urbanmachine.build/Vema-deconstruction-and-urban-machine-join-forces
[58] Vema Deconstruction. (2024). Retrieved June 23, 2024, from https://Vemadeconstruction.com/
[59] Urban Machine. (2024). The Machine. Retrieved June 23, 2024, from https://urbanmachine.build/the-machine

landscaping, setting an example for the private sector.
    - Example: Urbanjacks leaves trucks or bins to be filled with wood at CRD sites and film sets, and subcontracts wood removal services to deliver wood at their facility. Urbanjacks then upcycles the discarded wood scraps turning it into finger-jointed lumber.
- Encourage business models similar to Urbanjacks and Vema Deconstruction that focus on deconstructing wooden structures and selling reclaimed wood back to the industry.
- Support efforts of local businesses in source separation like Sea to Sky Removal that focus on source separation as a service, akin to on-site removal.

2. Source Separation Policy Recommendations

(2.1) Economic and Regulatory Incentives

- Introduce economic incentives, such as tax breaks and rebates, to encourage the use of recycled materials.
    - Example: The EU Circular Economy Action Plan promotes sustainability and waste reduction. In France, businesses selling recycled wood products benefit from a reduced Value-Added Tax rate, making these products more competitive than those made from virgin materials.[60]
- Impose fines for non-compliance with responsible wood waste management to deter unsustainable practices.
    - Example: In New South Wales, Australia, businesses that fail to follow the Protection of the Environment Operations Act (POEO Act) waste management regulations, including the proper disposal and recycling of wood waste, face substantial fines. The Environmental Protection Authority (EPA) enforces these regulations to ensure sustainable waste management practices.[61]

(2.2) Standardize Policies and Support Innovation

- Develop comprehensive and standardized policies at provincial or national levels to support effective sorting and separation practices.
    - Example: Germany enforces strict regulations under its Circular Economy Act which requires the separation of wood waste into different categories, such as untreated, treated, and hazardous wood.[62]

(2.3) Community Engagement

- Promote community involvement in waste management initiatives and

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[60] Ellen MacArthur Foundation. (2022, September 12). France's anti-waste and circular economy law. Retrieved June 23, 2024, from https://www.ellenmacarthurfoundation.org/circular-examples/frances-anti-waste-and-circular-economy-law

[61] New South Wales Environment Protection Authority. (2021). Solid waste landfills: Compliance audit program. NSW Environment Protection Authority. Retrieved from https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/licensing/20p2248-landfills-compliance-audit-summary.pdf

[62] European Environmental Bureau. (2020, March 25). Explained: Europe's new laws for separate waste collection. Retrieved from https://eeb.org/library/explained-europes-new-laws-for-separate-waste-collection/

collaborate with local businesses to drive improvements.

- Foster partnerships with maker spaces and reuse wood warehouses to promote the reuse of recovered materials.
    - Example: Green Innovation and Industrial Development (GRiiD) is a local collaborative initiative aimed at fostering green innovation and economic development within the False Creek Flats area of Vancouver. It promotes circular initiatives such as waste collection, repurposing, and redistribution in the city's industrial hub.[63]
    - Example: Ontario's Materials Marketplace launched by the Great Lakes Region in 2021, connects with a network of 2,000 businesses across North America to facilitate the resale of manufacturing materials. This local marketplace and dedicated sorting centre facilities the collection, storage and redistribution of salvage and surplus construction materials.[64]

(2.4) Enhance Education and Capacity Building for Effective Sorting

- Launch social systems campaigns to raise public awareness about the importance and benefits of on-site wood material sorting and implementing deconstruction practices.
- Develop and deliver comprehensive training programs and workshops: These should be tailored to different stakeholder groups (e.g., construction workers, site supervisors, demolition crews) and cover topics like:
    - Identification of different wood types and grades
    - Proper sorting techniques for various wood products
    - Understanding contamination issues and how to avoid them
    - Best practices for on-site storage and handling of sorted wood
- Promote the distribution and awareness of CRD source separation toolkits and effective signage for industry workers to implement on site.

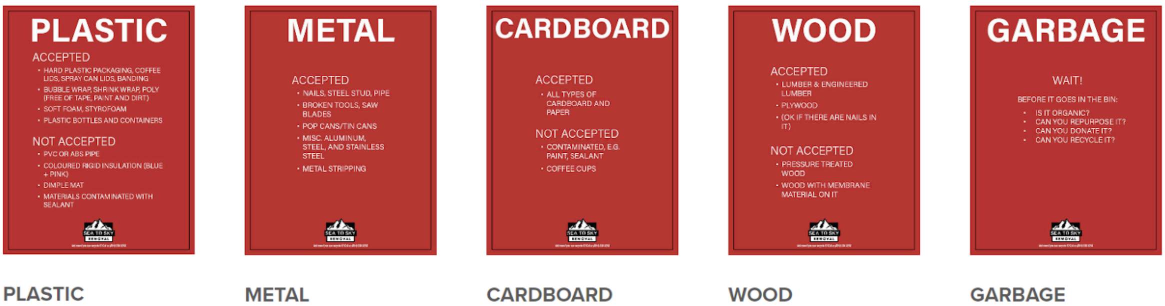

Figure 3: Image of Signage From Sea to Sky Removal's Recycling Toolkit

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[63] Bursey, K. (2020). Mapping the GrIID: The Global Reporting Initiative Impact Database (Report No. 2020-096). University of British Columbia. Retrieved from https://sustain.ubc.ca/sites/default/files/2020-096_Mapping%20the%20GrIID_Bursey.pdf

[64] Lopoukhine, R. (2024). Developing a circular building materials system and fostering innovation from construction, demolition and renovation (CRD) waste: An Ontario-focused systemic policy analysis and blueprint for change. Retrieved from https://circularinnovation.ca/wp-content/uploads/Developing-a-Circular-Building-Materials-System-and-Fostering-Innovation-from-Construction-Demolition-and-Renovation-CRD-Waste-COIL-CIC.pdf

Design for Disassembly

Designing with intentional consideration for the extended lifespan of buildings and the materials within them is crucial for reducing the linear use and disposal of wood. This approach involves creating durable structures and planning for potential disassembly or upgrades in the future. Designing for disassembly or deconstruction embraces circular design principles and ensures the long-term value retention of wood materials.

Successful local and international DfD projects demonstrate alignment with broader sustainability goals by reducing carbon emissions and enhancing material efficiency. For example, Nexii, a Vancouver-based green building company, creates modular panels designed with DfD principles that can offset 68% of the embodied carbon associated with building manufacturing.

By advocating for and integrating DfD strategies, businesses and policymakers can significantly contribute to sustainable building practices, reducing environmental impact while promoting economic efficiency and resilience in the construction sector.

3. Design for Disassembly Businesses Recommendations

(3.1) Leverage Building Information Modeling (BIM) and Digital Tools

- BIM and digital tools are essential for the construction industry. These technologies streamline the construction process, improve collaboration among project stakeholders, and facilitate the recovery of valuable materials at a building's end of life.
- BIM adoption can be implemented by encouraging the utilization of BIM software, material passports, and digital product passports.
- Standardize data templates and protocols for BIM models and other digital records to ensure that information about building materials, components, and systems is consistently organized and accessible to all project stakeholders throughout a building's lifecycle. This interoperability is crucial for efficient deconstruction and material recovery processes later on.
- Use digitization to track building materials and components throughout their lifecycle, aiding in the identification and recovery of reusable elements at a building's end of life.
    - Example: Vema Deconstruction employs SCAN (Survey, Confirm, Analyze, and Navigate) to BIM technologies to gather detailed building information prior to deconstruction.[65]

(3.2) Encourage Material Parsimony

- Promote the use of homogeneous materials by minimizing the types of materials used in building products, and simplifying recycling and reuse processes. An example of this in action would be encouraging the use of natural building materials like pure heritage lumber over MDF which is made up of a complex

[65] Interview with Erick Serpas Ventura, Founder of Vema Deconstruction, conducted on March 19, 2024.

mix of organic and manmade compounds.
    - Example: The Bullitt Center, known as the world's greenest commercial building, exemplifies material parsimony by extensively using FSC-certified heavy timber for its structure.[66]

(3.3) Prefabrication and Modular Design

- Support prefabrication and modular design to enhance the ease of disassembly and relocation of building components, preserving embodied carbon and extending the life cycle of materials.
    - Example: Brock Commons Tallwood House at the University of British Columbia was built by Urban One Builders and Structurlam using prefabricated wood panels and modular construction techniques. Each floor was assembled in just three days, demonstrating the efficiency and ease of prefabrication.[67]

4. Design for Disassembly Policy Recommendations

(4.1) Promote DfD Principles through Education

- Collaborate with industry stakeholders to develop comprehensive guidelines for DfD design and construction practices tailored to the Metro Vancouver regional context. These guidelines should include best practices, case studies, and technical specifications to ensure that DfD principles are effectively implemented.
- Organize workshops and training programs to educate architects, engineers, and contractors about DfD principles and best practices.
    - Example: Light House in Vancouver offers training programs, workshops, and seminars to collaborate with industry stakeholders to develop guidelines and case studies.[68]

(4.2) Mandate DfD and Recycling

- Collaborate with municipal and provincial authorities to incorporate DfD principles into building codes and standards. This could include requirements for material labelling, design for deconstruction, and documentation of building materials and components.
    - Example: Singapore's Building and Construction Authority (BCA) promotes green building practices via theSingapore Green Building Masterplan policies which include designing for adaptability and ease of disassembly to facilitate future retrofitting or redevelopment.[69]
- Provide regulatory support for the adoption of digital modelling and construction

[66] WA, D. C. in S. (2013). Bullitt Center. Retrieved from Bullitt Center website: https://bullittcenter.org/
[67] Brock Commons Tallwood House | Campus as a Living Lab. (n.d.). Retrieved from livinglabs.ubc.ca website: https://livinglabs.ubc.ca/projects/brock-commons-tallwood-house
[68] Our Services - Light House. (2023, January 19). Retrieved June 24, 2024, from https://www.light-house.org/our-services/?section=4
[69] Singapore Building and Construction Authority. (2023). Green Building Masterplans. BCA Corp. Retrieved from https://www1.bca.gov.sg/buildsg/sustainability/green-building-masterplans

technologies to inspire investment in sustainable practices.
- Implement financial incentives, such as tax breaks for using recycled materials, and penalties for excessive waste to motivate sustainable practices.

(4.4) Provide Financial Incentives and Support

- Offer tax incentives, grants, and low-interest loans to developers and builders who adopt DfD principles in their projects. This could include tax breaks for using recycled materials, grants for DfD training programs, and financial support for pilot projects.
- Provide subsidies for the use of sustainable, recyclable, and locally sourced building materials to reduce the cost barrier for developers and encourage widespread adoption of DfD practices
  - Example: Sweden has integrated circularity into its national building regulations, offering financial incentives such as grants and subsidies aimed at reducing the economic barriers to adopting DfD principles in construction projects.[70]

(4.4) Lifecycle Considerations and Material Parsimony

- Require Life Cycle Assessment (LCA) reporting to allow builders to see material impacts before completion, enabling reductions in embodied emissions.
  - Example: The French Environmental Regulations of 2020 mandate life LCA reporting for new buildings, spanning raw material production through the building's operations, and into their waste or re-use when the building is no longer operational. Initial LCA is mandatory during the construction permit application, with detailed information required upon finalizing the design.[71]

Conclusion

This report by the Circular Roots Collective, engaged by the National Zero Waste Council as part of a BCIT Sustainable Business leadership consulting project, addresses the significant issue of wood waste in the Metro Vancouver region's CRD sector. The research highlights the need for innovative solutions, emphasizing Designing for Disassembly (DfD) and effective source separation to maximize material recovery and reuse.

Key recommendations include incorporating DfD principles, utilizing advanced sorting technologies, and recognizing the need for comprehensive policy reforms that support circular practices. Economic market incentives are also crucial to encourage sustainability in this sector. Furthermore, enhancing education and building community

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[70] Bergström, G., & Save-Öfverholm, U. (2021). Swedish Sustainable Building. In Research – Development – Innovation – Implementation. Retrieved from https://www.formas.se/download/18.462d60ec167c69393b91e53c/1549956093043/Formas_SB11_brochure.pdf

[71] French laws are decarbonising the building sector – could they provide a way forward internationally? (2023, September 13). Stora Enso. Retrieved from https://www.storaenso.com/en/newsroom/news/2023/9/re2020

capacities will ensure people are equipped with the necessary skills and knowledge to implement these strategies effectively.

By adopting these multifaceted strategies, the Metro Vancouver region can reduce waste, conserve wood resources, and create economic opportunities. These efforts will help drive the circular economy in the CRD sector and further integrate sustainable construction and waste management practices into the future of this sector.

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Appendices

Appendix I: Desktop Research Questions

Section 1: Current Methodology and Challenges

1. What are the current methodologies of wood waste recycling in the CRD industry, looking at the Metro Vancouver region including the processes involved and the challenges faced, such as technological, economic, and regulatory barriers that impede recycling efforts?

Section 2: Innovative and Circular Solutions

2. What are the successful businesses, technologies, and circular solutions globally that enhance wood waste recycling?

Section 3: Product Innovation from Recycled Wood

3. How has product innovation from recycled wood materials contributed to enhancing the recycling (upcycling) process? What impact does this innovation have on the quality, durability, and market acceptance of the resulting products? Additionally, how do these innovative products, derived from recycled wood, create value and demand within the market?

Appendix II: List of Interviewees

S. No	Name	Title	Organization
1	Peter Moonen	National Sustainability Manager	Canadian Wood Council
2	Kaia Nielsen	Graduate Student	University of British Columbia
3	Erick Serpas Ventura	Founder	Vema Deconstruction
4	Kinsey Elliot	Engagement Specialist	Recycling Alternative
5	James Donaldson	CEO	Canadian Wood Waste Recycling Business Group
6	Jorie Wilsnefski	Marketing Manager	Urban Machine
7	Helen Goodland	Principal, Head of Research and Innovations	Scius Advisory
8	Matthäus Hermann	Co-Founder	Urbanjacks
9	Stephanie Dalo	Program Manager	Zero Emissions Innovation Center
10	Sheila Molloy	Executive Director	Coast Waste Management Association
11	Andrew Telfer	Director	Circular Innovation Council
12	Adrian Lopera-Lopera-Valle	Circular Innovation Lead	Light House
13	Christian Dietrich	Vice President, Recycling and Waste Management	Ecowaste
14	Zosia Brown	Vice President, Sustainability	Nexii Building Solutions
15	Chris Arkell	Co-Founder	Sea to Sky Removal
16	Jose Matas	Global Director - Wood Segment	TOMRA Recycling

Appendix III: Interview Questions

Section 1: CRD Wood Waste Source Separation

1. In your experience, what are the essential solutions required to ensure the effective sorting and separation of CRD wood waste?
2. Could you highlight any leading technological innovations or processes that are currently making a significant impact?
3. Could you identify the major barriers in the wood sorting process and how your organization or others are addressing these challenges?
4. Looking ahead, how do you see technological innovations shaping wood waste management over the next five years?
5. Are there any promising developments or trends that you believe will drive progress?"
6. What are the key indicators or measurements of success for effective sorting and separation of CRD wood waste in your view?

Section 2: Design for Deconstruction

1. Can you share any examples of how design for deconstruction principles have been integrated into building projects, either locally or globally? Can you discuss any challenges and successes these projects encountered?
2. What are the main barriers to adopting design for deconstruction in the building industry, and what innovations or policy changes do you think could overcome these challenges?
3. How do you envision the design for deconstruction influencing sustainability and waste management in construction over the next decade? What policy, market, or technological changes are necessary to support this shift?
4. What metrics or indicators would you use to evaluate the success of integrating design for deconstruction principles into construction projects? From your perspective, what does the future of sustainable construction look like with these principles?

Section 3: MDF Recycling

1. Regarding MDF recycling, what technological innovations or process improvements have significantly enhanced the efficiency or effectiveness of recycling efforts?
2. Are there examples of cost-effective or competitive approaches that have been particularly successful?
3. How does your organization gauge and respond to market demand for products made from upcycled MDF? Can you share strategies or insights on aligning with market needs?

4. Reflecting on your experience, what is reasonable to achieve in terms of improving MDF recycling processes and outcomes?
5. Additionally, could you discuss any notable obstacles or barriers that have impeded progress in this area?"
6. From your perspective, what does success look like for the future of wood waste management and MDF recycling?
7. How do we bridge the gap from where we are now to where we need to be, considering technological, market, and regulatory factors?

Appendix IV: Medium-Density Fiberboard Management

MDF presents a significant challenge in innovative circular practices, particularly in the context of CRD waste. As highlighted by sustainability experts and industry professionals, MDF is not considered valuable for traditional recycling or waste-to-energy (WtE) processes.

This section advocates for a strategic shift towards recovering wood fibers at the end of their life to be efficiently reprocessed to create new fiberboard, drawing on insights from European practices and the perspective of Jose Matas, a wood recycling expert on deep learning sorting technology from TOMRA Recycling

MDF: A Challenging Waste Material

In Canada, MDF recycling on an industrial scale has been considered. The complex composition of MDF, which includes resin and adhesives to improve moisture resistance and bonding, complicates the separation process required for effective recycling.[72] Experts interviewees have pointed out that the recycling infrastructure in places like the Metro Vancouver region is currently inadequate to handle MDF, leading to its frequent disposal in landfills.

The economic viability of MDF recycling is also a significant barrier, as the cost of recycling often exceeds the production of new MDF. According to Jose Matas, in Europe this barrier is linked to the legislation of a given country or region which determines the necessity to collect and recycle a material.

Challenges with Waste-to-Energy

There is a trend towards using wood and waste energy in Canada's manufacturing sector. While there is the potential to justify the use of wood to reduce reliance on other fossil fuels, this practice creates continued demand for wood resources to incinerate and is not a circular solution.

The Case Against Waste-to-Energy for MDF

While WtE solutions are sometimes proposed for MDF, this approach is problematic for several reasons:

- **Environmental Concerns:** The resins and adhesives in MDF can release harmful emissions when incinerated, contributing to air pollution and undermining environmental sustainability goals.
- **Energy Efficiency:** MDF has a lower calorific value compared to other waste materials, making it an inefficient source of energy.

[72] Unilin. (n.d.). Recycling MDF. Retrieved June 19, 2024, from https://www.unilin.com/en/recycling-mdf

- **Policy Implications:** Advocating for WtE could divert attention and resources from more sustainable recycling and upcycling initiatives.

Upcycling MDF into Furniture Material

According to Fortune Business Insights' report, the global market size for MDF was valued at USD 38.25 billion in 2020 and is projected to grow from USD 39.04 billion in 2021 to USD 57.11 billion by 2028.[73] A more sustainable and economically viable approach is to capture MDF's resurgence by upcycling into furniture and panels. This strategy aligns with circular economy principles and addresses several key issues:

- **Material Recovery:** Upcycling preserves the material integrity of MDF, transforming it into valuable products rather than discarding it as waste.
- **Economic Viability:** Upcycled MDF products can command higher market prices, making the process economically attractive.
- **Sustainability:** This approach reduces the environmental impact associated with both MDF disposal and the production of new materials.

The Role of TOMRA Recycling and Advanced Sorting Technologies

TOMRA Recycling, a leader in sensor-based sorting technology, offers reverse vending machines that can significantly enhance MDF recovery and upcycling processes. Their advanced systems can efficiently separate MDF from other CRD waste, improving material quality and reducing contamination. By integrating TOMRA Recycling's technology, recycling plants can increase their processing efficiency and product quality, making upcycling a more feasible option. Introducing TOMRA advanced wood sorting machine, utilizing cutting-edge technology to enhance recycling efficiency and material recovery. New technologies like TOMRA's machines utilize advanced technology to enhance recycling efficiency and maximize material recovery. For over a decade, TOMRA's AI wood systems have utilized deep learning and X-ray vision to sort materials like MDF from chipped wood with precision.

[73] Zimmer, A., & Lunelli Bachmann, S. A. (2023). Challenges for recycling medium-density fiberboard (MDF). Results in Engineering, 19 , 101277. https://doi.org/10.1016/j.rineng.2023.101277

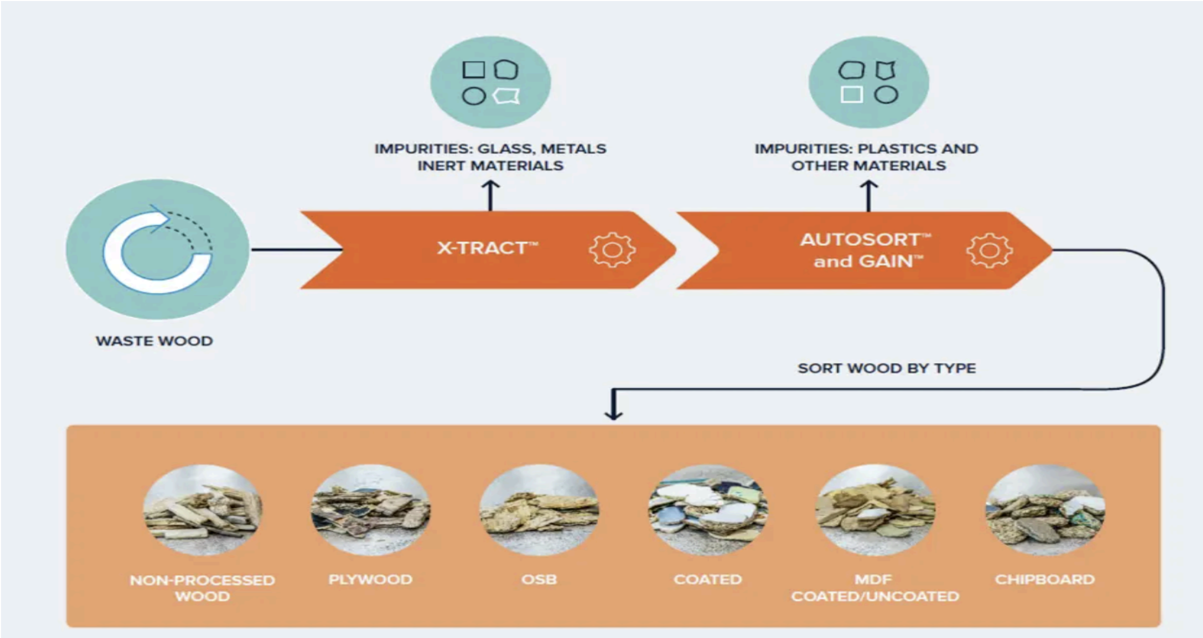

Figure 4. Image of TOMRA Systems Technology Wood Sorting Process

Learning from European Practices and Industry Leaders

In Europe, the circular economy framework has driven innovations in MDF recycling and upcycling. Jose Matas believes that over the next decade, recycling technologies and practices will evolve to handle materials like MDF more effectively. By studying and adopting these practices, the Metro Vancouver region can improve its own waste management strategies.

Sustainability Case for Recycling Plants and Machines

Investing in recycling plants and machines tailored for MDF upcycling can yield substantial long-term benefits:

- **Economic Growth:** Establishing facilities for MDF upcycling can create jobs, stimulate local economies, and attract investments in green technologies.
- **Market Expansion:** Upcycled MDF products can tap into the growing market for sustainable furniture and building materials, appealing to environmentally conscious consumers.
- **Policy Alignment:** Such investments align with local and national sustainability goals, helping to achieve regulatory compliance and secure financial incentives.

Going Forward

MDF presents significant challenges in traditional waste management and is not suitable for WtE processes. Instead, upcycling MDF into furniture and other high-value products offers a sustainable and economically viable alternative. By leveraging advanced sorting technologies from companies like TOMRA Recycling and adopting best practices from Europe, the Metro Vancouver region can transform its CRD waste management approach. This strategy will not only reduce environmental impact but also drive economic growth and align with broader sustainability objectives. In summary, to understand MDF:

- Interview Canadian sustainability experts on circular wood waste management, especially on composite boards about the current market analysis and their economic potential.
- Gain insights from global circular economy practices.
- Learn from technology solutions like TOMRA Recycling and similar wood sorting companies.