Identifying Gaps and Challenges of Using Building Integrated Modelling (BIM) for Embodied Carbon Accounting

WORKSHOP REPORT

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AUTHORSHIPS

This report was prepared by the University of British Columbia (UBC) Smart Structures Team and the Sustainable Built Environment Lab, under funding received through the UBC Sustainability Hub. The project aims to identify gaps and challenges in the use of Building Information Modeling (BIM) for embodied carbon accounting and Life Cycle Assessment (LCA). This report presents the outcomes of a workshop session on Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting, held on October 24, 2024.

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DISCLAIMER

Opinions, recommendations, and any errors contained in this report are solely those of the authors and do not necessarily represent the views of the participating institution or the University of British Columbia. Input provided by the building professionals and the experts reflects their perspectives and does not necessarily reflect the official stance of their respective organizations.

LAND ACKNOWLEDGEMENT

The Sustainability Hub office is located at the UBC Point Grey campus, situated on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam). As part of the larger UBC community, we are guests and settlers on the traditional, ancestral, and unceded territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), Sel̓íl̓witulh (TsleilWaututh), and Syilx (Okanagan) Nations.

In our pursuit of sustainability, climate action and climate justice, we understand that protecting human rights is indelibly woven into environmental protection and sustainability.

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The "**Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**" project, led by The University of British Columbia's Smart Structures Team from the Department of Civil Engineering and Sustainable Built Environment Lab from the Department of Wood Science, aimed to address barriers in integrating Building Information Modeling (BIM) with embodied carbon accounting.

Phase one of this project included a literature review and interviews with BIM and Life Cycle Assessment (LCA) experts, which informed the design of Phase two— a collaborative workshop held in October 2024. The workshop was facilitated by UBC researchers and engaged 18 experts from various organizations through structured discussions and activities, including group discussions on challenges and solution development. Participants shared their insights on technical and practical complexities, explored innovative solutions, and identified actionable steps for advancing BIM's use in environmental impact assessments. This effort emphasized creating a collaborative platform to foster effective building practices and tailored solutions for Canada's unique needs.

The building sector in Canada accounts for 12% of the country's greenhouse gas (GHG) emissions, a figure that could rise to 18% if embodied carbon emissions are included (Environment and Climate Change Canada (ECCC), 2024). Embodied carbon, mainly driven by material extraction, production, and construction, significantly contributes to Canada's overall emissions. Reducing it through the use of low-carbon materials, such as wood products, low-carbon concrete, and recycled steel is important to achieving Canada's net-zero goals by 2050. Early-stage material selection and the use of tools like LCA and BIM can simplify the evaluation of environmental impacts and reduce embodied carbon. However, challenges such as a lack of standardized data, complex integration of BIM and LCA, and limited regulations hinder progress.

The Pathways to Net-zero Embodied Carbon in Buildings, led by the UBC Sustainability Hub, is a federally funded project that identifies challenges for implementing embodied carbon into a policy context while testing innovative solutions to address some of these challenges. A key part of this project was the research on "Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting", aiming to advance the integration of BIM and embodied carbon accounting in Canada. This research has two phases:

Phase One was a research work to identify key gaps and challenges in use of BIM for embodied carbon accounting.

Phase Two, built on findings from Phase One, involved stakeholder engagement and collaborative workshops to explore solutions for the challenges. One such workshop, "**Workshop on Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**", brought together building professionals to develop actionable strategies for improving BIM-based embodied carbon accounting. The outcomes are expected to guide future research, inform industry practices, and strengthen frameworks for reducing embodied carbon in Canada's building sector.

The key objectives of the workshop were as follows:

- **Identify Challenges:** Pinpoint the barriers in using BIM for embodied carbon accounting, including technical inefficiencies, data quality issues, and workflow challenges.
- **Develop Solutions:** Explore actionable strategies to enhance BIM-LCA integration, focusing on policy frameworks, tool development, and collaborative practices.
- **Promote Collaboration:** Facilitate cross-sector partnerships to share knowledge, align practices, and support the adoption of sustainable construction methods.
- **Enhance Education and Awareness:** Raise awareness among practitioners and policymakers about embodied carbon accounting and its potential to contribute to sustainability.

Participants engaged in discussions that highlighted a range of technical, policy, and adoption barriers currently limiting the widespread use of BIM-LCA workflows. These challenges span issues such as tool interoperability, data consistency, and the lack of standardized protocols, as well as broader systemic hurdles like inadequate policies and insufficient financial incentives. In addition to identifying these barriers, the workshop explored innovative solutions and actionable strategies to address them, emphasizing the role of technology, collaboration, and policy alignment in driving progress. Below is a summary of the key topics discussed during the workshop.

1. **Technical Challenges:**
    - Poor interoperability between BIM and LCA tools.
    - Inconsistent and incomplete data sets, particularly material libraries.
    - Workflow inefficiencies requiring manual data adjustments.
2. **Policy and Regulatory Gaps:**
    - Lack of standardized BIM practices and government mandates for BIM-LCA integration.
    - Insufficient financial incentives for adopting sustainable practices.
3. **Adoption Barriers:**
    - High software costs and limited training for practitioners.
    - Reluctance to integrate LCA into early design phases due to complexity and lack of tools.
4. **Solutions and Innovations:**
    - Potential of AI to automate data mapping and enhance workflows.
    - Importance of centralized databases for Environmental Product Declarations (EPDs) and benchmarking.

Participants also emphasized the need for targeted policy interventions, technological advancements, and capacity-building initiatives to develop a cohesive and scalable approach for integrating BIM with embodied carbon accounting. Recognizing that no single solution can address all challenges, the discussions underscored the importance of aligning regulatory frameworks, investing in advanced digital tools, and fostering cross-sector collaboration among key stakeholders, including building owners, developers, designers, contractors, city officials, and government entities. These integrated efforts are essential for enabling the construction industry to reduce its carbon footprint effectively while meeting national and global climate goals. The following key recommendations were outlined in the report:

1. **Policy Alignment:**
   - Federal and provincial governments should mandate the integration of BIM-LCA workflows into building codes for large-scale projects to standardize practices and enforce sustainability targets.
   - Governments at all levels should introduce financial incentives, such as grants and tax credits, to encourage developers and contractors to adopt sustainable practices.
2. **Technological Advancements:**
   - Software developers and research institutions should create AI-driven tools to streamline workflows, improve data accuracy, and automate complex processes.
   - Professional associations and standardization bodies should invest in centralized material libraries and promote open standards like Industry Foundation Classes (IFC) to enhance interoperability across platforms.
3. **Capacity Building:**
   - Educational institutions and professional organizations should implement targeted training programs for designers, engineers, contractors, and policymakers to develop technical expertise in BIM and embodied carbon practices.
   - Advocacy groups and public agencies should raise public awareness about the importance of embodied carbon impacts and the role of BIM in reducing these emissions.
4. **Collaborative Frameworks:**
   - Industry stakeholders and public-private partnerships should strengthen cross-sector collaboration to enable resource sharing, knowledge exchange, and joint problem-solving.
   - Project teams and owners should adopt Integrated Project Delivery (IPD) models to align stakeholder incentives and promote sustainability-focused project outcomes.

The workshop findings underscore the critical need for a collaborative, multi-stakeholder approach to overcoming the barriers to BIM integration for embodied carbon accounting. Federal and provincial governments must lead by establishing mandates and financial incentives, while software developers and industry professionals play a pivotal role in advancing technologies and standards. Educational institutions and advocacy groups should drive capacity-building efforts, and project teams must adopt collaborative frameworks to align sustainability goals across all stages of the construction process. By working collectively, these stakeholders can ensure that today's efforts not only reduce greenhouse gas emissions but also pave the way for a sustainable and economically viable future for Canada's construction sector. The workshop highlighted key barriers and proposed solutions, with plans to publish findings, guide policy updates, and support the Pathways project. Future efforts will need to address tool compatibility, data quality, and unresolved challenges, such as improving early-stage BIM models and biogenic carbon calculations, through collaboration with experts.

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GLOSSARY OF TERMS

Artificial Intelligence (AI): The simulation of human intelligence processes by machines, particularly computer systems. AI encompasses a variety of capabilities, including learning, reasoning, problem-solving, and perception, and is widely used in applications such as robotics, machine learning, and decision-making.

Application Programming Interface (API): A set of rules and protocols that allows different software applications to communicate with each other. APIs enable developers to access the functionalities or data of an application, operating system, or service without having to understand its internal workings.

Bills of Quantities (BoQs)/ Bills of Materials (BoMs): The process of calculating and listing the quantities of materials needed for a construction project, often derived directly from the BIM model.

Building Information Modeling (BIM): A digital representation of the physical and functional characteristics of a facility. BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its lifecycle, from conception to demolition.

Biogenic Carbon: The carbon that can be produced in natural processes by living organisms, but not fossilized or derived from fossil resources. The carbon can be stored in biological materials such as wood (ISO, 2017).

Embodied Carbon Emissions: Total emissions associated with materials and products in a built asset throughout a part or all building life cycle stages. These emissions exclude operational and water use.

Environmental Product Declarations (EPD): EPDs are third-party-verified documents that report the environmental impacts of a product. They often represent impacts associated with raw materials extraction, product manufacturing, and transportation and distribution (NRC, 2022).

Industry Foundation Classes (IFC): A standardized, open data model used for describing, sharing, and exchanging building and construction data across different software platforms. IFC is commonly employed in BIM to enable interoperability and collaboration among various stakeholders in the construction industry.

Large Language Models (LLM): Advanced machine learning models designed to understand, generate, and process human language at scale. LLMs, such as Generative Pre-trained Transformer (GPT), are trained on vast amounts of text data and can perform tasks like summarization, translation, and content creation across multiple languages and domains.

Life Cycle Assessment (LCA): A systematic set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a product, including buildings and their materials, throughout its life cycle (NRC, 2022).

Low-Carbon Materials: Building materials that are designed, produced, and used with the goal of minimizing their embodied carbon, such as recycled materials, low-carbon concrete, or sustainably sourced timber.

Materials Carbon Accounting: Embodied carbon emissions from materials production and construction phases.

Natural Language Processing (NLP): A subfield of artificial intelligence that focuses on the interaction between computers and human language. NLP involves techniques for analyzing, understanding, and generating text or speech in a way that is meaningful and useful, enabling applications like sentiment analysis, machine translation, and voice recognition.

Net-Zero Carbon: A building or product that balances its carbon emissions with carbon removal or offset, resulting in a net-zero contribution to atmospheric CO2 levels over its lifecycle.

Operational Carbon: Emissions associated with energy used to operate buildings.

Whole Building Life Cycle Assessment (WBLCA): LCA applied to a whole building.

ABBREVIATIONS

AI | Artificial Intelligence

API | Application Programming Interface

BIM | Bill of Materials

BoM | Bill of Quantity

BoD | Community Energy and Emissions Plan

ECCC | Environment and Climate Change Canada

EPD | Environmental Product Declaration

GHG | Greenhouse Gas

LCA | Life Cycle Assessment

NRC | National Research Council Canada

WBLCA | Whole Building Life Cycle Assessment

IFC | Industry Foundation Classes

IPD | Integrated Project Delivery

ISO | International Organization for Standardization

LLM | Large Language Models

NLP | Natural Language Processing

The building sector is Canada's third-largest source of GHG emissions, contributing 12% of the country's total emissions, following transportation and oil and gas (ECCC, 2024). This figure only reflects operational emissions, such as those from energy use during a building's lifecycle. When embodied carbon emissions from the extraction, production, transportation, and assembly of materials are considered, the sector's impact rises to 18% (NZAB, 2023). Reducing embodied carbon is essential to aligning the construction industry with Canada's climate goals (NRC, 2022). However, the industry currently faces significant challenges, including limited focus on material sustainability and outdated building standards (ECCC, 2022). Addressing these gaps is critical to promoting low-carbon construction practices and supporting the transition to a net-zero future. Choosing materials early in the design stage is crucial for making Canada's construction process more sustainable, aiming for net-zero emissions goals by 2050 (Government of Canada, 2023).

Low-carbon materials can greatly reduce a building's carbon footprint, but their environmental impacts must be carefully evaluated, considering both initial carbon savings and long-term effects (RMI, 2023). LCA can help to evaluating the environmental impacts of materials and processes throughout a building's entire lifecycle for material selection. By analyzing stages such as material extraction, production, transportation, use, and end-of-life disposal, LCA provides a comprehensive picture of embodied carbon emissions. This approach enables practitioners to identify hotspots in the material supply chain and construction processes, guiding them toward more sustainable alternatives. While LCA is essential for emissions accounting, manually calculating these impacts for every building component is time-intensive and prone to inaccuracies (Canada Green Building Council (CAGBC), 2021).

Calculating emissions from construction materials can be complex. Integrating BIM with LCA represents a promising solution to overcome the complexities of embodied carbon accounting (PSPC, 2023). BIM offers a transformative way to improve the efficiency and accuracy of embodied carbon analysis. It is a digital tool that creates detailed 3D models of a building, incorporating both physical and functional information. BIM enables stakeholders to collaborate across disciplines and manage building data throughout the project lifecycle. It supports early-stage decision-making by allowing professionals to simulate various design and material options, assess their performance, and predict their environmental impacts.

By combining the detailed data from BIM models with the analytical capabilities of LCA, practitioners can automate the calculation of emissions, saving time and improving precision. This integration allows building professionals to compare material choices based on structural performance, durability, and environmental impact, supporting informed decision-making in line with Canada's net-zero goals (ISED-ISDE Canada, 2023; CanBIM, 2024). By linking BIM with LCA, practitioners can move beyond isolated calculations to a dynamic, data-driven approach that aligns design decisions with sustainability goals. However, challenges remain, including the need for standardized data, specialized tools, and better interoperability between software platforms.

The University of British Columbia's "Pathways to Net-zero Embodied Carbon in Buildings" is a two-year project led by UBC Sustainability Hub to address challenges and pilot innovative solutions to reduce embodied carbon emissions from buildings. "**Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**" project is one of the sub-projects that aims to address these challenges by advancing the integration of BIM and embodied carbon accounting in Canada. Phase One of the project identified several key gaps, including the lack of standardized data for Canadian materials, limited expertise in integrating BIM with LCA tools, and insufficient regulatory support to incentivize low-carbon practices. These findings have informed Phase Two of the project, which focuses on exploring solutions through stakeholder engagement and collaborative workshops.

As part of Phase Two, "**Workshop on Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**" was organized to bring together building professionals to identify actionable strategies for improving BIM-based embodied carbon accounting. Participants discussed technical solutions, such as improving data integration and interoperability, as well as policy changes to support sustainable material use. The workshop outcomes are expected to inform future research, guide industry practices, and help develop a more robust framework for reducing embodied carbon in Canada's building sector.

In order to find the gaps and challenges faced by building professionals including the government of Canada, "**Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**" project was conducted by the UBC Smart Structures from the Department of Civil Engineering and the Sustainable Built Environment Lab from Department of Wood science as a part of the Pathways project with UBC Sustainability Hub. The primary activities started with a literature review and involved interviews and collaborative workshops, for knowledge exchange sessions with building professionals and policymakers. The goal was to address the challenges associated with using BIM for embodied carbon accounting and to develop solutions acceptable across various industry sectors. In Phase One of the project, a comprehensive literature review was performed, and selective BIM and LCA experts from different institutions were interviewed. The insights from Phase One were used to develop the concept for the second phase, to find the key challenges and possible solutions.

Phase Two involved the workshop, "**Workshop on Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**", held in the fall 2024. The workshop session was facilitated by PhD students from UBC's Civil Engineering and Wood Science departments. Dr. Haibo Feng, from UBC's Department of Wood Science, delivered a presentation outlining the gaps and challenges identified in Phase One of the project. This was followed by structured discussion sessions led by the facilitators to engage participants in exploring these challenges further. The workshop gathered 18 experts in BIM, including professionals from UBC's Civil Engineering and Wood Science departments, Athena Sustainable Materials, National Research Council Canada, HCMA Architecture + Design, Recollective Consulting, ZGF Architects, ReLoad Sustainable Design, and CLF BC. Participants engaged in interactive activities and discussions, sharing insights, and outlining steps to advance solutions. Some participants had previously contributed during the interview phase, while additional experts were reached through the UBC Sustainability Hub and its network. The two-hour workshop was held virtually via Zoom on October 24, 2024.

The workshop followed a structured agenda:

1. **Introduction:** The workshop began with facilitators introducing the project, highlighting its objectives and agenda. Dr. Haibo Feng delivered an in-depth presentation on the integration of BIM in embodied carbon accounting. The session also included a summary of key findings from Phase One of the project, focusing on identified gaps and proposed solutions.

2. **Activity 1:** Two small group discussions were conducted, each with 8 to 9 participants, focusing on challenges. A Miro board activity was used to organize ideas from each participant. The first 10 minutes were dedicated to individual input, where participants placed their ideas on the board. This was followed by a 15-minute group discussion to prioritize challenges requiring immediate solutions. After the first activity, all participants reconvened in the main group for a report-back session, during which the challenges identified by each group were shared and discussed collectively.

3. **Activity 2:** The second activity focused on identifying solutions for the key challenges and gaps highlighted during the first session. Working in the same small groups, participants listed potential solutions on the Miro board. Each group collaboratively selected the most suitable solutions, considering their feasibility and relevance. Participants also discussed the practicalities of implementing these solutions and shared potential resources to support their application.

4. Follow-up Discussion: A whole group discussion followed, allowing both small groups to present their proposed solutions and elaborate on their importance and implementation feasibility. This session provided an opportunity for cross-group dialogue and collective refinement of ideas.

5. Ending Note: The discussion concluded with an outline of the next steps and a review of the expected outcomes, ensuring alignment on future actions and goals.

Participants were expected to explore both practical issues and theoretical complexities faced by professionals. The workshop also sought to create a collaborative space for brainstorming innovative solutions tailored to Canada's needs, ultimately advancing sustainable building practices that effectively integrate BIM technology.

Key Objectives of Workshop:

1. Bring together experts from various fields to pinpoint and tackle major gaps and challenges in using BIM for embodied carbon accounting.
2. Expand on Phase One findings to further explore and confirm challenges across different disciplines.
3. Facilitate collaborative discussions to:
    - Explore potential solutions to identified challenges.
    - Prioritize solutions requiring immediate implementation.
4. Develop clear, actionable steps to improve BIM integration for embodied carbon accounting and promote continuous practice enhancements.

This report details the discussions and outcomes of the workshop, including the proposed solutions and recommended actions to address the identified challenges in using BIM for embodied carbon accounting.

The workshop discussions provided a platform for participants to explore the key gaps and challenges in integrating BIM with embodied carbon accounting. Experts from building professionals shared insights on issues such as data inconsistencies, limited interoperability between tools, and the need for standardized workflows and accessible data. Collaborative discussions led to identifying actionable solutions, including improving software integration, enhancing practitioner training, and prioritizing early-stage embodied carbon considerations. Participants also highlighted opportunities for cross-sector collaboration to share resources and pilot innovative approaches, laying the groundwork for focused activities to address these challenges.

ACTIVITY 1: IDENTIFYING CHALLENGES

Two small group discussions were conducted to delve deeper into the challenges associated with using BIM for embodied carbon accounting. Each group consisted of 8 to 9 participants, and Miro board activity was employed to facilitate the organization and visualization of ideas contributed by participants. During the initial 10 minutes, each participant independently placed their ideas on the board, providing a broad range of viewpoints and ensuring that all voices were heard. This phase allowed individuals to reflect on their experiences and articulate specific challenges without external influence.

Following this, the groups engaged in a 15-minute collaborative discussion to evaluate and prioritize the challenges identified. This focused dialogue encouraged participants to assess the urgency and impact of each challenge, ultimately narrowing the list to those requiring immediate attention. The structured approach fostered productive exchanges and a consensus-driven prioritization process.

After completing the small group discussions, all participants reconvened in a plenary session. During this report-back session, each group shared the challenges they identified and prioritized. This collective discussion provided an opportunity to compare findings, highlight common themes, and explore differing perspectives. The session also set the stage for subsequent activities by ensuring that all participants had a shared understanding of the key challenges requiring further exploration.

TECHNICAL CHALLENGES

Technical Challenges by Breakout Group A

Regarding technical challenges, participants from Breakout Group A identified several issues stemming from high costs, compatibility problems, and inconsistent adoption. For instance, expensive licenses for BIM software like Autodesk Revit place a financial strain on firms, particularly for smaller projects, where cost efficiency is critical. Furthermore, the lack of standardization across different LCA tools often results in varying outcomes, making accurate comparisons difficult. Additionally, the limited adoption of BIM software within the design community creates disparities in workflows, complicating collaboration and data sharing. Aligning BIM and LCA data is another challenge, as it often requires manual intervention due to mismatches in structure and insufficient granularity for LCA needs, such as embodied carbon and energy use. These issues are compounded by poor interoperability between tools, forcing analysts to adapt models manually, which significantly increases their workload.

Data quality issues also undermine the accuracy of lifecycle assessments. For example, outdated or missing material libraries in BIM models lead to incomplete analyses, while structural and architectural models are often misaligned, creating discrepancies that must be addressed. Additionally, materials in BIM models are frequently misidentified or oversimplified, making detailed analysis difficult. Aggregated components, such as concrete walls, require separate material takeoffs, while architectural inaccuracies can overestimate or underestimate materials. Consequently, these inconsistencies highlight the urgent need for standardized practices in material detailing and modelling.

During the workshop discussions, participants identified key challenges in early-stage projects, primarily the lack of detailed BIM models or sufficient granularity, which makes accurate quantity takeoffs challenging. They highlighted those missing details, such as wall layers, often forcing analysts to rely on assumptions. This reliance, participants noted, reduces precision and makes analyses in the early phases assumption-heavy. These gaps, according to the participants, can lead to significant deviations from actual outcomes, complicating decision-making in later stages of the project.

It is also observed that workflow inefficiencies exacerbate these issues. BIM exports often include unnecessary elements that require manual adjustments, while overly granular models need simplification to ensure usability. Additionally, non-standardized modelling practices and shortcuts, such as using 2D drawings instead of 3D BIM models, were noted by the team as significant contributors to reduced data quality. Double counting across overlapping disciplines was also cited by both participants and the research team as a recurring challenge.

Lastly, LCA challenges include incomplete data for lifecycle stages and misaligned milestone timings. Many tools fail to cover all lifecycle phases, such as construction process stage A4 (transport to the building site) and A5 (installation into the building), complicating reporting and reducing the reliability of the analysis. Effective collaboration between design and analysis teams is crucial to ensure data availability at key milestones. Moreover, robust visualization capabilities are needed to provide actionable insights and help reduce embodied carbon. Without these improvements, the potential of LCA as a decision-making tool remains limited.

Table 1: Technical challenges and key challenges identified by Breakout Group A.

Technical Challenges Identified	Key Challenges Identified
1. **Poor Interoperability** • BIM and LCA data require manual alignment. • Inconsistent LCA tool results. • Limited BIM adoption. 2. **Data Quality Issues** • Outdated or incomplete material libraries. • Misalignment of structural and architectural models. • Misidentified or oversimplified materials. • Aggregated or inaccurate architectural components. 3. **Workflow Inefficiencies** • Manual adjustments for BIM exports. • Overly granular models. • Non-standard practices. • Use of shortcuts like 2D models. 4. **Early-Stage Challenges** • Lack of detailed BIM models. • Missing details. • Assumption-heavy analyses. 5. **LCA Challenges** • Incomplete data for lifecycle stages. 6. **Monetary Challenges** • High-price BIM software license. • No monetary incentive on small-scale projects.	1. **BIM Model Complexity and Accuracy** 2. **Integration of BIM and LCA** 3. **Data Requirements and Modeling Practices**

Technical Challenges by Breakout Group B

For the technical challenges, participants from Breakout Group B highlighted concerns about the lack of uniformity in BIM modelling practices, where varying approaches across contributors on large projects can make it difficult to conduct an LCA directly from the model. One participant noted that "everyone models differently," which often leads to inconsistencies, particularly on larger projects involving multiple stakeholders. Additionally, challenges with quantity calculation accuracy at different design stages were noted, with earlier stages requiring broad assumptions and later stages being more precise but still prone to errors.

The group also addressed the critical need for standardizing BIM processes, including data collection, mapping, and processing, as well as the terminology and naming conventions used within models. One participant added a comment about the importance of matching LCA scopes with BIM takeoff schedules to streamline workflows. Another participant emphasized the necessity of creating a bi-directional relationship between BIM and LCA tools to enhance data exchange and reduce information loss during integration. Validation of Industry Foundation Classes (IFC), a digital standard for describing the built environment, against LCA requirements, was also identified as an essential step for maintaining data integrity.

Software differences emerged as a significant barrier, with participants pointing out inconsistencies in calculation methods, Environmental Product Declarations (EPDs) selection, and the handling of quantities across platforms. An EPD is a standardized document that provides verified, transparent information about the environmental impact of a product throughout its lifecycle, including data on carbon footprint, energy use, and other environmental metrics. These discrepancies in EPD selection and interpretation can lead to variations in results, complicating decision-making processes. One participant shared an example illustrating how such inconsistencies affect the reliability of assessments.

The group also identified the steep learning curve for practitioners new to BIM-LCA integration and the lack of a common database for centralized data access as major barriers to wider adoption. Additionally, the group discussed challenges surrounding biogenic carbon calculations, with one participant emphasizing the need for standardized methodologies to ensure accurate and consistent sustainability assessments.

Amid these discussions, participants reached a consensus on the most critical challenges facing BIM-LCA integration:

- **Building BIM Model Complexity and Accuracy:** The inherent complexity of BIM models and the difficulty in ensuring their accuracy create significant obstacles for their effective use in LCA.
- **Mandating BIM Standards Across Sectors:** Mandating standards like the International Organization for Standardization (ISO) is particularly challenging due to the varied requirements and capabilities across different sectors and industries.
- **Conflicting Priorities of BIM Models:** BIM models are primarily designed for use in design and construction, which often conflicts with their role in LCA. This conflict arises because LCA is typically added as a secondary layer rather than being integrated as a core component of the modelling process.

These key challenges, identified with the agreement of all participants, highlight the foundational barriers that must be addressed to advance the integration of BIM for embodied carbon accounting. Breakout Group B's discussion provided valuable insights into these challenges and laid the groundwork for exploring actionable solutions in subsequent activities.

Table 2: Technical challenges and key challenges identified by Breakout Group B.

Technical Challenges Identified	Key Challenges Identified
1. **BIM Data Accuracy and Standardization** • Challenges with BIM data accuracy for LCA studies. • Quantity calculation accuracy issues, particularly during early and late design stages. • BIMs are design interpretations, not contract documents, which can limit accuracy. • Standardizing the process of data collection, mapping, and processing. • Lack of standardization for elements and product naming in BIM models. • Need for standardized language and terminology in BIM for consistent communication. • Difficulty in validating IFC against LCA requirements. 2. **Integration of BIM and LCA Tools** • Difficulty in integrating BIM files into LCA tools without data loss. • Matching the LCA scope with takeoff schedules from BIM models. • Establishing a bi-directional relationship between BIM and LCA for better feedback and iteration. 3. **Data Requirements and Modeling Practices** • Identifying minimum data requirements in BIM models for effective LCA studies. • Variability in modeling practices across large projects with multiple contributors, creating challenges for LCA. • Broad assumptions needed during earlier design stages due to limited data. 4. **Learning Curve and Software Challenges** • Steep learning curve in understanding and implementing BIM-LCA integration. • Lack of a common database to streamline data collection and use. • Software differences affecting calculation results, EPD selection, and quantity accuracy. 5. **Biogenic Carbon and Sustainability Metrics** • Inconsistent methods for calculating biogenic carbon. 6. **Overarching Challenges** • Comments on accuracy, particularly with data limitations and inconsistencies.	1. **BIM Model Complexity and Accuracy** 2. **Mandating BIM Standards Across Sectors** 3. **Conflicting Priorities of BIM Models**

GAPS FOUND IN BIM PRACTICES IN LCA

Gaps in BIM-LCA Integration by Breakout Group A

Breakout Group A found that architects and consultants often lack access to critical data, such as manufacturer details and EPDs, during early design stages. Consequently, they must rely on contractors to provide this information later, which delays decisions and complicates efforts to integrate sustainability into the design process.

They also identified that the absence of standardized protocols for data transfer between BIM and LCA tools creates inconsistencies, both across and within companies. This not only complicates collaboration but also increases inefficiencies and errors, ultimately undermining the effectiveness of BIM-LCA integration, with one participant describing the process as "more art than science," which highlights the challenge of making informed early-stage decisions.

Using BIM for LCA requires extra work, such as manual data adjustments, which adds to consultants' workloads. However, because there are no clear incentives like financial rewards or recognition, many consultants are reluctant to prioritize these tasks, limiting the adoption of LCA practices and their potential to support less embodied carbon emission designs.

Group A identified several gaps in using BIM for LCA, including a lack of essential data, uncertainties in early-stage decision-making, inconsistent data transfer protocols, and additional workload without clear incentives.

Table 3: Gaps and key gaps identified by Breakout Group A to implement BIM in embodied carbon calculation.

Gaps in BIM Practices in LCA Identified	Key Gaps Identified
1. **Lack of Essential Information** • Insufficient EPDs. 2. **Uncertainty in Early-Stage LCA** • Limited data in the early stage. 3. **No Standardized Protocols for BIM-LCA Integration** • No standardized process and protocol for data transfer between BIM and LCA within companies. 4. **Additional Effort Without Incentives** • No financial rewards or recognition.	1. **Data uncertainty.** 2. **Incentive alignment.**

Gaps in BIM-LCA Integration by Breakout Group B

Breakout Group B focused on identifying gaps in BIM practices for embodied carbon accounting, emphasizing key issues in policy, tools, workflows, and awareness. Participants discussed the lack of government support and the absence of a standardized policy for adopting BIM in Canada, highlighting the need for regulatory frameworks to ensure consistent practices. One participant added a comment on the importance of standard nomenclature (naming and classifying construction products), noting that "inconsistent language and terminology across projects often create significant barriers to seamless integration of BIM and LCA." The limitations of IFC in hosting data related to products, activities, and machine operations were also highlighted, with suggestions to improve its capabilities to support more comprehensive data exchange.

Tool development emerged as another critical topic, with participants identifying the need for expanded EPD and benchmark libraries to support decision-making. One participant emphasized the inconsistencies between existing tools, sharing an example where results varied significantly across platforms, complicating data reliability. Another participant mentioned the inefficiency of the typical two-step export and import process for quantities, which often requires extensive data "clean-ups," slowing down workflows.

Discussions also addressed the challenges of applying BIM-LCA during the early design stage. Participants agreed that obtaining quick and accurate results at this stage is difficult, with one participant raising concerns about the accuracy of steel plate calculations in mass timber buildings. Another participant added that "BIM-LCA integration at the early design stage is crucial but is often hindered by the lack of appropriate tools and processes."

The group explored the potential of advanced technologies like AI and large language models (LLMs) for automating data mapping and enhancing workflows. However, they noted that these technologies remain underutilized in current practices. Participants also highlighted the importance of increasing awareness among designers, owners, and the public about the embodied carbon impacts of their decisions, with one participant stating, "Education and knowledge sharing are essential to drive meaningful change in how BIM and LCA are implemented."

Breakout Group B's discussion provided valuable insights into the multifaceted gaps in BIM practices for embodied carbon accounting. The feedback and shared experiences from participants underscored the urgency of addressing these challenges through targeted policy, improved tools, streamlined workflows, and increased stakeholder awareness.

Table 4: Gaps and key gaps identified by Breakout Group B to implement BIM in embodied carbon calculation.

Gaps in BIM Practices in LCA Identified	
1. **Policy and Regulation** • Lack of government support • Absence of a standard policy for adopting BIM in Canada. • Need for BIM regulation to ensure consistency and reliability in practices. 2. **Standardization and Tool Development** • Need for a standard nomenclature • IFC limitations in hosting data related to products, activities, and machine operation. • Inconsistencies between tools in handling data and outputs. • Expansion of EPD libraries and the development of benchmark libraries for better comparison and decision-making. 3. **Early Design Stage Limitations** • Difficulty in obtaining quick and accurate results during the early design stage. • Limitations in using BIM-LCA effectively to guide early-stage decisions. • Issues with the accuracy of steel plate calculations in mass timber buildings during the early design stage.	4. **Workflow Challenges** • The typical two-step export and import process for quantities involves extensive 'clean-ups', reducing efficiency. • Insufficient collaboration with Quantity Surveyors, who are often contracted for accurate data, with unclear integration of their workflows and software into BIM practices. 5. **Advanced Technologies** • Potential for AI integration to enhance workflows and automate tasks. • Exploration of technologies like large language models (LLMs) and natural language processing (NLP) for data mapping and processing. 6. **Knowledge and Awareness** • Limited designer, owner, and public understanding of embodied carbon impacts and the role of BIM-LCA integration in addressing these impacts.
Key Gaps Identified	
1. **Lack of Tool development (e.g., AI)**	

ACTIVITY 2: DEVELOPING SOLUTIONS

The second activity was designed to build on the insights gained from the first session, shifting the focus from identifying challenges to exploring actionable solutions. Working within the same small groups as in the previous activity, participants began by listing potential solutions to address the key challenges and gaps highlighted earlier. Using the Miro board, they visually organized their ideas, enabling an open and creative brainstorming process. This approach was intended to ensure that a wide range of possible solutions was considered, leveraging the expertise and perspectives of the group members.

Once the potential solutions were compiled, each group collaboratively assessed their feasibility and relevance to the identified challenges. Through guided discussions, participants evaluated the practicality of implementing each solution in real-world scenarios, considering factors such as resource availability, stakeholder engagement, and compatibility with existing workflows. This process enabled the groups to select the most promising solutions with a balance of innovation and applicability.

In addition, participants engaged in discussions about the specific requirements for implementing these solutions, including identifying potential barriers and opportunities for support. They shared knowledge about available resources, such as software tools, data sources, and training programs, that could facilitate the adoption of the proposed solutions. This collaborative effort provided a clear and actionable framework for addressing the challenges, setting the stage for the next steps in the workshop.

SOLUTIONS FOR IDENTIFIED CHALLENGES

Solutions by Breakout Group A

Breakout Group A discussed practical solutions to address interoperability and collaboration challenges in using BIM for LCA. Emphasizing interoperability standards, such as IFC, was identified as critical for enabling better communication and compatibility between software systems. Early-stage coordination among disciplines is essential, often initiated by sharing memos to establish BIM models with standard modelling practices for collaboration. Stakeholders must adopt BIM software to create more accurate models, supported by cloud-based platforms like BIM 360, which can integrate LCA calculations and enhance team collaboration.

To improve interoperability, participants discussed developing open Application Programming Interfaces (API) s and plug-ins is a key solution. An API is a set of rules and protocols that allows different software applications to communicate and share data with one another. Open APIs, in particular, are designed to be publicly accessible, enabling third-party developers to create tools and integrations that enhance connectivity and functionality between systems. By leveraging open APIs and plug-ins, software developers can create seamless, user-friendly data exchange systems. Additionally, comprehensive training and knowledge sharing are crucial to ensure practitioners are proficient in using BIM tools and understand data exchange processes. This bridges the gap between technical capabilities and practical applications, fostering smoother collaboration and improved outcomes.

Standardizing BIM data structures for LCA methodologies, including material property databases, is essential. Templates should define the required level of detail and information for BIM models. To focus on the broader impact, focused studies of material embodied carbon should be prioritized over whole-building Life Cycle Assessments (wbLCA).

Streamlining processes by integrating efforts such as cost estimation, LCA, and energy modelling was also emphasized. Each discipline should take responsibility for its own quantity take-offs, supported by standard modelling practices to ensure consistency and accuracy. Automated checks, such as verifying that roof areas align with floor areas, can improve reliability, while revised guidelines with expanded scopes address evolving project needs. For final-stage LCA, obtaining fabrication models and quantities from trades is essential to achieve precision and better outcomes.

Breakout Group A proposed solutions to improve interoperability and collaboration in use of BIM for LCA, emphasizing the adoption of interoperability standards like IFC, cloud-based platforms, open APIs, and comprehensive training to enhance data exchange and collaboration. They also highlighted the need to standardize BIM data structures, prioritize material embodied carbon studies, streamline processes by integrating cost estimation and energy modelling, and implement automated checks and fabrication models used for greater accuracy and reliability.

Table 5: Solutions identified for the technical challenges and immediate implementation identified by Breakout Group A.

Solutions for Identified Challenges	Immediate Implementation
1. **Enhance Interoperability** • Emphasize standards like IFC. • Develop APIS and plug-ins. • Promote cloud-based platforms. 2. **Improve Coordination and Training** • Standardize BIM Practices. • Provide Training and Knowledge Sharing. 3. **Standardize BIM for LCA** • Build database. • Create templates for required detail and information. • Prioritize material embodied carbon. 4. **Streamline Processes** • Integrated parameters. • Implement automated checks for data accuracy. • Obtain fabrication models for precise final-stage LCA outcomes.	1. **Integrated platform.** 2. **Focus on interoperability standards like IFC.** 3. **Direct LCA calculations.**

Solutions by Breakout Group B

Breakout Group B delved into potential solutions for the key challenges identified in integrating BIM with embodied carbon accounting. Participants emphasized the need for addressing BIM model complexity and accuracy, suggesting that firms should coordinate their BIM models from the beginning to support LCA requirements. One participant added a comment, stating, “Developing a guideline on how to structure BIM models for LCA from the outset could significantly reduce inaccuracies and streamline workflows.” The group also explored the role of AI in enhancing model accuracy, automating tasks like data validation and mapping, and overcoming challenges in complex BIM processes. For scenarios where integration remains problematic, participants noted that manual take-offs could serve as a temporary workaround to ensure reliable data extraction.

Addressing the issue of mandating BIM standards across sectors, participants proposed implementing moderate regulations that consider the unique needs of different industries. One participant suggested leveraging programming language-based applications for example using Python integrated with BIM tools, emphasizing that such tools must follow consistent, agreed-upon standards to ensure widespread usability. Another participant noted, “Building sector-specific applications can offer flexibility while maintaining alignment with overall BIM-LCA goals.”

To resolve the conflicting priorities of BIM models, participants highlighted the importance of technical training for designers and engineers to align BIM use for both design and LCA needs. One participant commented, “Providing targeted training will help practitioners integrate LCA considerations early in the design process without compromising other priorities.” Additionally, the group underscored the value of standardized guidelines to balance the demands of design and construction with the inclusion of embodied carbon considerations in BIM workflows.

Breakout Group B identified three immediate solutions to address pressing challenges in integrating BIM with LCA. First, they emphasized the need to clarify whether BIM should be optional or mandatory for projects involving LCA, suggesting that clear guidelines could provide consistency and encourage broader adoption. Second, participants highlighted the potential of AI to streamline the integration process by automating data mapping, enhancing model accuracy, and reducing manual effort.

One participant noted that “AI could significantly simplify workflows and address inconsistencies, making BIM-LCA integration more efficient.” Lastly, the group underscored the importance of targeted training programs for designers, engineers, and other stakeholders. These programs should focus on equipping practitioners with the skills needed to effectively integrate LCA considerations within BIM workflows, helping to overcome technical barriers and improve implementation outcomes.

Breakout Group B’s discussion provided actionable solutions, emphasizing the role of coordination, innovation, and education in overcoming key challenges. The group’s insights set the foundation for practical strategies to advance the integration of BIM for embodied carbon accounting.

Table 6: Solutions identified for the technical challenges and immediate implementation identified by Breakout Group B.

Solutions for Identified Challenges	Immediate Implementation
1. **BIM Model Complexity and Accuracy** • **Coordinated Model Development:** Firms successfully using BIM for LCA have coordinated their models from the beginning to align with LCA needs. Developing guidelines on how to structure BIM models for LCA from the outset could provide a standardized approach. • **AI Integration:** Leveraging AI technologies to enhance model accuracy and automate tasks, such as data validation and mapping, can address issues with complexity and inaccuracies. • **Manual Take-Offs as a Backup:** For projects where BIM integration poses significant challenges, manual take-offs can be used as an interim solution to ensure accurate data extraction. 2. **Mandating BIM Standards Across Sectors** • **Moderate Regulation:** Implementing moderate BIM regulations tailored to sector-specific needs can provide a balanced approach, ensuring consistency without overburdening industries with strict mandates. • **Python Applications for Customization:** Building Python-based applications that integrate with BIM tools can enable sector-specific customization while adhering to agreed-upon standards. This approach can enhance flexibility while promoting consistency across applications. 3. **Conflicting Priorities of BIM Models** • **Technical Training:** Providing targeted technical training for designers and engineers on integrating LCA needs within BIM models can bridge the gap between design/construction priorities and LCA requirements. • **Standardized Guidelines:** Establishing clear guidelines for balancing design and construction priorities with LCA integration can help reduce conflicts and ensure that both objectives are met efficiently.	1. **Using AI to integrate BIM with LCA** 2. **Training for the stakeholders**

IMPLEMENTATION FOR IDENTIFIED GAPS

Implementation of Solutions by Breakout Group A

Breakout Group A focused on identifying solutions to address the existing gaps in the automation of data mapping and classifications between BIM and LCA systems. Additionally, the group explored how collaborative project delivery models, such as Integrated Project Delivery (IPD), can effectively tackle the issue of incentive alignment, ensuring that all stakeholders are motivated to work towards shared sustainability and efficiency goals.

On the policy level, the group emphasized the importance of mandating BIM standards with explicit requirements for incorporating LCA practices, particularly for projects that exceed specific thresholds, whether defined by cost, or by scope. Such mandates would create a structured framework for integrating LCA into the project design and delivery processes.

Moreover, the group proposed that LCA reporting should be made a mandatory requirement for larger projects that surpass defined scales. This would ensure that the effort invested in sustainability practices is commensurate with the project's size and impact, while also aligning the incentives of all involved parties. By systematically embedding LCA practices into larger, more impactful developments, these policies aim to foster a culture of accountability and promote the adoption of practices across the construction industry.

Breakout Group A emphasized the need to bridge systemic gaps in integrating BIM and LCA processes through automation and collaborative frameworks, such as IPD, to align stakeholder incentives, and drive sustainability goals. The group also highlighted the importance of policy measures, including mandating BIM standards with LCA reporting policy.

Table 7: Solution identified for the gaps and immediate implementation identified by Breakout Group A.

Implementation for Gaps Identified	Immediate implementation
1. **Addressing Automation Gaps** • Automating data mapping and classifications between BIM and LCA. 2. **Collaborative Project Delivery Models** • Mandating BIM Standards • BIM standards that include explicit LCA requirements for projects exceeding certain thresholds. 3. **Mandating BIM Standards** • BIM standards that include explicit LCA requirements for projects exceeding certain thresholds. 4. **Mandatory LCA Reporting** • Mandatory LCA reporting on large-scale to align sustainability efforts with project impact, ensuring systematic integration of practices.	1. **Policy establishment** 2. **Automation and alignment**

Implementation of Solutions by Breakout Group B

Breakout Group B focused on identifying solutions for the gaps and challenges in integrating BIM with embodied carbon accounting. A key priority was addressing the lack of tool development, with participants emphasizing the need for software capable of reading a BIM bill of materials (BoM), filling data gaps, and generating BoMs ready for LCA. One participant added a comment, stating, “Consistency in software and LCA assumptions is crucial to ensure reliability across projects and avoid conflicting results.” The group also discussed the role of AI in enhancing workflows, noting its potential for automating data mapping and detecting inconsistencies. However, another participant pointed out that “AI might not do all the work for designers but can be a valuable tool to support and augment their efforts.”

In terms of policy and regulation, participants highlighted the importance of federal, provincial, and local regulations to support the adoption of BIM-LCA practices. They agreed that technical solutions should be developed first to guide policy, with one participant noting, “Policy should follow innovation, not lead it, to ensure it aligns with practical, technical capabilities.” The group also recognized the potential for benchmarking through larger-scale project data collection to influence future policy directions.

The discussion further emphasized the need for training incentives to encourage practitioners to adopt BIM-LCA workflows. Participants identified potential synergies in workflows, such as aligning LCA tasks with the scope of cost estimators, to improve efficiency. Accessibility was also a recurring theme, with the group agreeing that no-cost tools must be available to practitioners. One participant commented, “Developing and maintaining free tools will require funding, but it’s essential for reducing barriers and promoting widespread adoption.”

Breakout Group B identified two immediate solutions to address the gaps in integrating BIM with embodied carbon accounting. First, participants emphasized the importance of AI integration to automate workflows, enhance data mapping, and detect inconsistencies, with one participant noting that “AI can serve as a powerful support tool to augment, not replace, designers’ efforts.”

Second, training was highlighted as critical, with targeted programs and incentives needed to equip practitioners with the skills to effectively integrate BIM and LCA into their workflows. Finally, the group stressed the need for benchmarking, advocating for systems to collect and analyze data from a larger number of projects. This approach would help establish performance baselines and provide insights to guide both industry practices and future policy development. These immediate solutions aim to address foundational challenges and accelerate progress in BIM-LCA integration.

Table 8: Solution identified for the gaps and immediate implementation identified by Breakout Group A.

Implementation for Gaps Identified	Immediate implementation
1. **Tool Development and Technological Advancements** • Develop software that reads a BIM bill of materials (BoM), fills gaps, and adds labels to make it ready for LCA. • Ensure consistency in software and LCA assumptions to streamline workflows and improve reliability. • Leverage AI detection capabilities to enhance data mapping, automate workflows, and identify inconsistencies. 2. **Policy and Regulation** • Federal, provincial, and local regulations are needed to guide the adoption of BIM and LCA integration effectively. • Develop technical solutions that support policy development, ensuring that policy follows technological innovation rather than leading it. • Explore the potential policy impacts of benchmarking through larger-scale project data collection. 3. **Training and Incentives** • Provide training incentives to encourage adoption and build capacity among practitioners. • Identify synergies in workflows, potentially integrating LCA tasks with the scope of cost estimators to streamline processes. 4. **Accessibility and Funding** • Ensure no-cost tools are available for practitioners to increase accessibility and reduce barriers to entry. • Secure funding to develop and maintain these tools, ensuring their reliability and long-term usability.	1. **AI Integration** 2. **Automation and alignment**

The concluding discussion synthesized the outcomes of the workshop sessions and highlighted the policy-oriented insights, challenges, and solutions identified for integrating BIM with embodied carbon accounting. The participants underscored the critical need for policy alignment, technical frameworks, and collaborative approaches to advance sustainable practices and facilitate the adoption of embodied carbon accounting within the built environment.

IDENTIFIED CHALLENGES AND GAPS

1. **Technical Challenges:**
    - **Interoperability:** The lack of seamless data exchange between BIM and LCA tools creates inefficiencies, with many processes requiring manual adjustments. Poor interoperability limits data accuracy and increases workload for practitioners.
    - **Data Quality:** Outdated material libraries, misalignment between architectural and structural models, and insufficient granularity in BIM models undermine the reliability of embodied carbon assessments.
    - **Early-Stage Limitations:** A lack of detailed BIM models during early design stages forces reliance on assumptions, reducing precision in embodied carbon calculations.ility of embodied carbon assessments.
2. **Workflow Inefficiencies:**
    - Participants highlighted the excessive manual effort required to clean and prepare data for LCA, which slows down workflows. Inconsistent modelling practices across stakeholders further exacerbate inefficiencies.
    - Double counting of data, overly granular exports, and the use of shortcuts like 2D drawings instead of 3D BIM models were cited as common issues.
3. **Technical Challenges:**
    - The absence of government-mandated standards for integrating BIM and LCA tools has resulted in inconsistent practices. This gap is particularly evident in the lack of standardized protocols for data transfer and the insufficient adoption of tools like IFC for interoperability.
    - Many municipalities lack clear regulatory authority to implement embodied carbon policies, making it difficult to enforce embodied carbon practices at a local level.
4. **Adoption Barriers:**
    - High software costs, limited financial incentives, and insufficient training discourage small firms and smaller-scale projects from adopting BIM-LCA workflows.
5. **Tool Development Needs:**
    - Current tools lack the ability to automate processes such as data mapping and validation, while inconsistencies in EPDs and lifecycle stages create further complications.

TECHNOLOGICAL ADVANCEMENTS AND TOOL DEVELOPMENT

Participants stressed the need for investment in advanced tools and technologies to overcome technical barriers:

1. **AI and Automation:**
   - Artificial intelligence can streamline data mapping, validate models, and automate error detection, reducing manual workload and enhancing workflow efficiency.
2. **Enhanced Tools and Databases:**
   - Tools capable of reading BoMs, filling data gaps, and generating LCA-ready outputs are critical for improving integration.
   - Expanding EPD libraries and developing centralized databases for benchmarking lifecycle data can enhance data reliability and accessibility.
3. **Workflow Integration:**
   - Investment in APIs, plug-ins, and cloud-based platforms that facilitate seamless integration between BIM and LCA tools is essential for improving interoperability and reducing inefficiencies.
4. **Accessibility:**
   - Governments and building professionals should ensure the availability of free or low-cost tools to reduce adoption barriers, particularly for smaller firms and projects.

COLLABORATIVE FRAMEWORKS AND INCENTIVES

Participants emphasized the importance of collaborative models to align stakeholder efforts and address incentive misalignment:

1. **Integrated Project Delivery (IPD):** IPD models can align project stakeholder incentives and foster collaboration among teams by creating shared goals for sustainability. These models encourage early engagement and streamline workflows across disciplines within a building project.
2. **Public-Private Partnerships:** Collaboration between governments, industry groups, and academic institutions can accelerate the development and adoption of innovative solutions, such as advanced tools and policy frameworks.
3. **Benchmarking and Performance Metrics:** Collecting data from a larger number of projects helps create benchmarks and performance metrics. These benchmarks can guide governments and policymakers in developing better policies. At the same time, the data provides valuable insights that building professionals can use to improve their work and make informed decisions.

The workshop's discussions provided a foundation for advancing BIM-LCA integration through coordinated policy, technology, and collaboration. Addressing technical barriers, aligning regulatory frameworks, and fostering education and collaboration are critical to enabling the built environment sector to reduce embodied carbon emissions effectively. With concerted action across all levels of government and the building professionals, these recommendations offer a pathway to meaningful progress in building a sustainable future.

KEY INSIGHTS

The workshop revealed that BIM has the potential to reduce embodied carbon emissions in construction by facilitating detailed lifecycle assessments and informed material selection. However, its integration faces critical challenges, including interoperability issues between tools, inconsistent and incomplete data, and a lack of standardized practices across the construction industry. These barriers limit its effectiveness and broader adoption. To maximize the potential of BIM in reducing embodied carbon, it is recommended to strengthen collaboration between key stakeholders, engineers, builders, architects, LCA analysts, and policymakers. Standardized data exchange protocols should be established, alongside policies that require the use of BIM for embodied carbon accounting in construction projects. Additionally, leveraging advanced technologies like AI could help streamline workflows, automate data mapping, and improve accuracy, making BIM a more practical and impactful tool for achieving sustainability goals.

RECOMMENDATIONS

The workshop discussions emphasized the need for a cohesive approach to overcoming the barriers to integrating BIM with embodied carbon accounting. Participants highlighted that bridging these gaps requires a combination of targeted policy interventions, technological innovation, and enhanced capacity-building initiatives. Key challenges identified included inconsistent adoption of standards, interoperability issues, and limited awareness among stakeholders. These challenges are further compounded by a lack of financial incentives and the absence of regulatory frameworks that mandate the integration of LCA into BIM workflows. Recognizing these complexities, participants proposed potential solutions to address technical, procedural, and policy barriers, ensuring a structured and scalable approach to advancing sustainability in the built environment.

To address these gaps, participants proposed targeted policy solutions that align technical innovation with regulatory frameworks to promote adoption and consistency:

PROPOSED POLICY-ORIENTED SOLUTIONS

1. **Mandating BIM Standards and Integration:**
   - Federal and provincial governments in Canada should introduce mandatory BIM standards that explicitly include LCA requirements. This can be scaled for larger projects to ensure significant sustainability impacts.
   - Policies should encourage sector-specific flexibility while maintaining consistency in overarching standards, such as the use of IFC for interoperability.
2. **Incorporating Embodied Carbon in Building Codes:**
   - Embodied carbon emission metrics should be embedded in building codes and zoning regulations by policymakers. This includes requiring lifecycle reporting as part of rezoning and permitting processes.
3. **Encouraging Regional Collaboration:**
   - Municipalities should leverage collective expertise to establish standardized policies and tools. For example, the collaboration between the Cities of Richmond and Vancouver on low-carbon concrete initiatives was highlighted as a model for fostering regional consistency and shared learning.
4. **Providing Financial Incentives:**
   - Government of Canada should introduce grants, tax credits, and subsidies to encourage adoption of BIM-LCA workflows. This approach can help alleviate cost barriers for small-scale projects and incentivize innovation.

EDUCATIONAL AND CAPACITY-BUILDING INITIATIVES

Education and training for architects and builders emerged as key themes to address gaps in knowledge and technical skills:

1. **Targeted Training Programs:** Tailored training programs should be developed to equip practitioners with the skills needed to integrate BIM with LCA effectively. These programs, led by architectural firms, engineering consultancies, BIM software providers (e.g., Autodesk, Trimble), and professional organizations, should address both technical and practical aspects, including data management, workflow optimization, and tool usage.

2. **Awareness Campaigns:** Raising awareness about the importance of embodied carbon accounting among building professionals is essential for fostering broader adoption. Stakeholders like green building advocacy groups, government agencies, educational institutions, and industry associations can lead educational materials development and public campaigns to demystify these concepts for a wider audience, including building owners.

3. **Knowledge Sharing Platforms:** Establishing forums for interdisciplinary collaboration, such as workshops, webinars, and curated resource hubs, can facilitate the exchange of best practices and drive innovation. Stakeholders such as construction industry associations, research institutions, and technology companies providing collaborative tools could organize and manage these platforms to maximize impact.

NEXT STEPS

The "**Identifying Gaps and Challenges of Using BIM for Embodied Carbon Accounting**" project has highlighted the barriers and proposed potential solutions to some of these challenges. To build on this work, the following steps are planned. A detailed research paper summarizing findings from Phases 1 and 2 will be published to foster collaboration among researchers, professionals, and policymakers. The findings will also support the Pathways to Net Zero Embodied Carbon Buildings project by addressing challenges related to tool compatibility, data quality, and workflows.

Furthermore, unresolved issues, such as enhancing early-stage BIM models and improving biogenic carbon calculations, should be further explored through collaboration with industry experts and academia. These initiatives aim to strengthen policies, improve practices, and drive innovation in reducing embodied carbon in construction.

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Appendix I: Attendees and interviewees information.

NAME	ROLE/ PROFESSIONAL TITLE	ORGANIZATION
Alex Mannion	Master student	The University of British Columbia
Ayme Sharma	Associate	ZGF Architects Inc.
Bahram Azizi	Architect	Azizi Architect Inc.
Dervash Bhonde	Postdoctoral Fellow	The University of British Columbia
Elise Woestyn	Director, Building Performance	HCMA Architecture + Design
Farzad Jalaei	Research Officer	National Research Council Canada
Haibo Feng	Assistant Professor	Department of Wood Science, UBC
Hugh Nolan	Building Energy & Carbon Analyst	Reload Sustainable Design Inc
Jennifer O'Connor	President at Athena Institute	Athena Sustainable Materials
Juan Rivera	Architect	HCMA Architecture + Design
Matthew Bowick	Senior Research Associate	Athena Sustainable Materials
Megan Badri	Research Manager	UBC Sustainability Hub
Molly Walsh	Sustainability/Building Performance Analyst	ZGF Architects inc.
Navid Hosseini	Principal, Chief Executive Officer	Recollective Consulting
Omar Swei	Associate Professor	Department of Civil Engineering, UBC
Stephanie Dalo	Program Manager	CLF British Columbia (Carbon Leadership Forum), ZEIC
Tim Meyers	Associate Principal	ZGF Architects Inc.
Tony Yang	Professor	Department of Civil Engineering, UBC

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