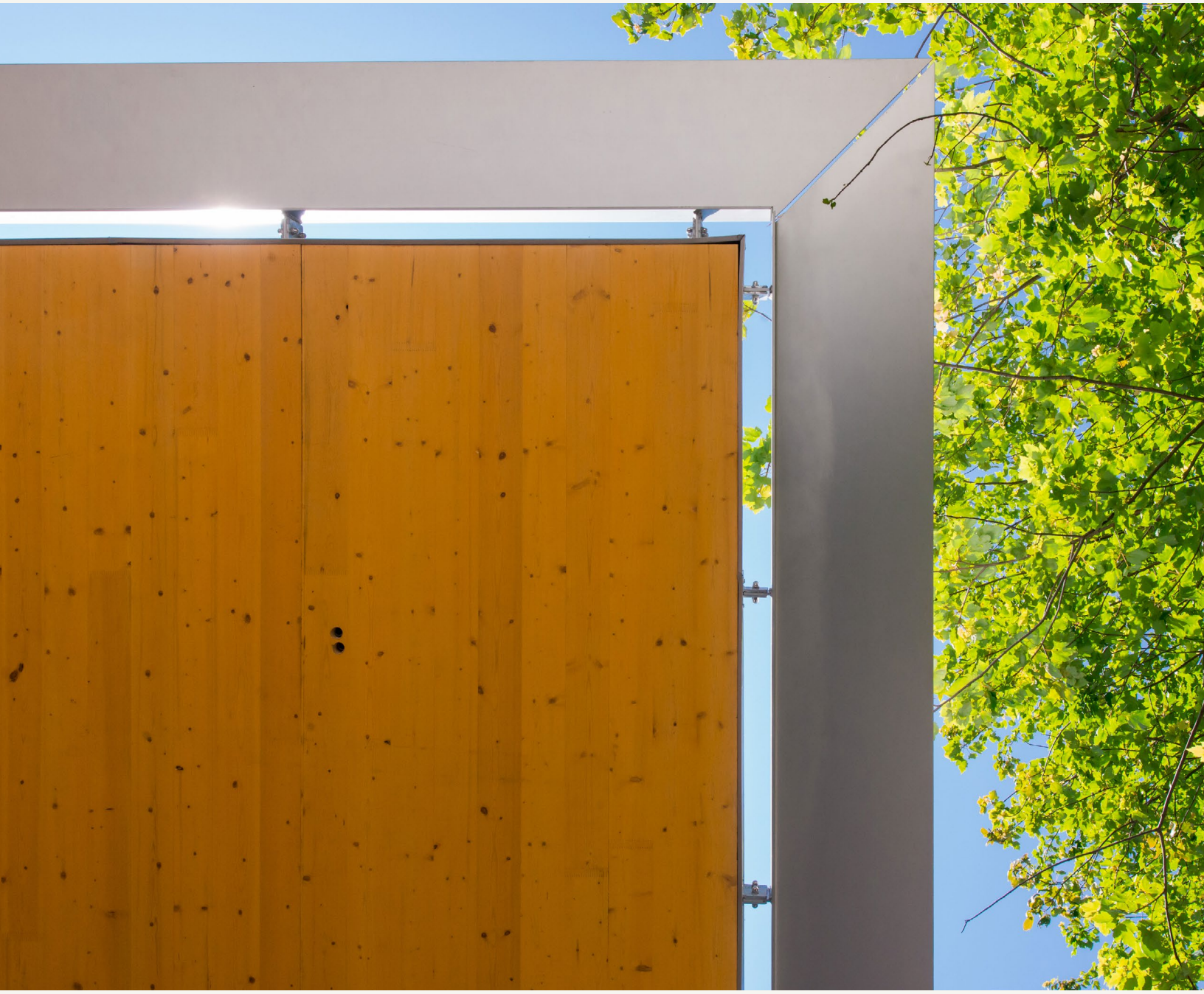
Pathways to Net-Zero Embodied Carbon in Buildings: Barriers and Solutions to Effective Policies and Actions

CHALLENGE-TO-SOLUTION WORKSHOP SERIES REPORT



THE UNIVERSITY OF BRITISH COLUMBIA
Sustainability Hub

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AUTHORSHIPS

This report was prepared by the University of British Columbia (UBC) Sustainability Hub as part of the "Pathways to Net-Zero Embodied Carbon in Buildings" project, which seeks to build local and regional collaborations and partnerships to identify immediate barriers and challenges to implementing embodied carbon policies and actions. The report describes the outcomes of the Pathways project's Challenge-to-Solution Workshop series conducted between November 10 and December 5, 2023.

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The cover photo of the UBC Earth Systems Science Building is courtesy of Don Erhardt.

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DISCLAIMER

The opinions, recommendations, and any errors in this report are those of the authors and do not necessarily reflect the views of the participating municipalities or the University of British Columbia.

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), Sc̓lí̓lwitulh (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 UBC's "Pathways to Net-zero Embodied Carbon in Buildings" is a two-year project led by the UBC Sustainability Hub. The project aims to build local and regional collaborations and partnerships to identify immediate barriers and challenges to implementing embodied carbon policies and actions; and to develop solutions to advance along the pathway to Canada's net-zero carbon emissions targets between 2030 and 2050. The project, funded by Environment and Climate Change Canada (ECCC), supports the Net-Zero Advisory Body's (NZAB) mandate to advise the federal Minister of Environment and Climate Change in achieving the 2050 net-zero GHG emissions goal. As part of this work, a series of workshops were conducted with representatives from local, provincial, and federal government agencies, industry, and academia.

The Challenge-to-Solution Workshops were a series of three two-part workshops to explore the challenges of implementing embodied carbon actions and policies in British Columbia and identify potential short and long-term solutions. The workshops were conducted virtually on Zoom between November 10 and December 5, 2023. They were led by the UBC Sustainability Hub, with assistance from Athena and ZEBx. The workshops facilitated discussions on three main overarching challenges with each workshop divided into two phases:

1. **Availability of data and access to low-carbon building products:** In Workshop 1, phase A, participants were asked to explore the challenges linked to the accessibility and usability of carbon emissions data in the selection and procurement of low-carbon materials. Participants were also asked to share their current workarounds and ideate potential systematic solutions to these challenges.

2. **Integration of building information, emissions assessment tools, and project delivery process in whole building LCAs:** In Workshop 2, phase A, participants were asked to share their perspectives on current challenges related to collecting and using primary data for whole building carbon emission assessments and the integration of carbon assessment tools into the building design, delivery process, and workflow. Participants were also shared their workarounds and brainstormed potential systematic solutions to these challenges.

Due to similarity in the discussion themes from the first two workshops, Workshop 1, phase B and Workshop 2, phase B were combined into a single session. In this integrated Workshop 1B+2B, participants developed a roadmap of potential actions that could be taken by different scales of government and/or industry to improve the availability and usability of emissions data for both products and whole buildings.

3. **Challenges and successes of policies and regulations related to low-carbon products and buildings:** In Workshop 3, phase A, participants were asked to provide inputs on challenges in developing and implementing policies and regulations to mainstream low-embodied carbon products and buildings. In Workshop 3, phase B, workshop participants identified successful local, provincial, and federal government policies and regulations that address building sector embodied carbon emissions. Further participants shared their insights on policy domains that may intersect with embodied carbon policies and how to strategically coordinate and align efforts across government levels.

As part of the workshop discussion, participants worked through current approaches and potential systemic solutions to the challenges in advancing embodied carbon emissions policies and practices for buildings. The discussions can be summarized in the following five themes of recommended actions:

1. **Create an effective embodied carbon policy ecosystem.** Policymakers across government levels and industry practitioners must collaborate to develop effective building sector embodied carbon policies to align with Canada's 2050 net-zero GHG emissions goals. This includes integrating embodied carbon emissions from buildings into national level GHG emissions tracking and into existing policy mechanisms such as carbon taxes, carbon caps, building codes, etc. In addition, efforts must be taken to adopt these approaches in ways that encourage retrofits and develop markets for materials reuse. Reliable emission data, for buildings and their products, as well as clear standards and guides are required to instrument the integration of embodied carbon emissions into effective policies.

2. **Increase access to consistent and comparable databases and LCA tools.** Tool developers must collaborate with policymakers and industry professionals to create LCA tools that are both user-friendly and provide transparent and up-to-date building product data. In addition, regular audits and third-party verification are essential to keep consistency and accuracy along LCA tools and databases.

3. **Incentivize low-carbon materials and buildings development.** Policymakers can encourage the use and supply of low-carbon products and buildings, along with the disclosure of product emissions data and building LCAs, by offering incentives to low-carbon alternative manufacturers and different building stakeholders to cover their additional costs associated with producing EPDs or conducting LCAs.

4. **Foster embodied carbon expertise through training and education.** Academic institutions, policymakers, and professionals need to collaborate to create and offer targeted training and educational materials tailored to building industry and policymakers. These initiatives should provide a comprehensive understanding of policies, regulations, standards, tools, and reporting, aimed at enhancing professionals' proficiency in navigating low-carbon building trade-offs. Further, they should facilitate a deeper comprehension among non-practitioners and policymakers, aiding them in grasping the underlying concepts more effectively.

5. **Test pathways to net-zero embodied carbon in buildings.** As embodied carbon policies are developed, testing and validating their requirements and results becomes important. Different levels of government should expand initiatives to use government or public funding projects to showcase best practices and create case studies to explore the effectiveness of different regulatory strategies. This step is essential for broader market development and industry progress for strong coordination and collaboration across different government levels and local authorities in the region.

The insights and recommendations collected from these workshops will enhance our understanding of the challenges and solutions related to embodied carbon policy and practices. This information will be used by the Pathways project team to develop research and knowledge mobilization pilots, inform future project activities and expand the projects' network of stakeholders. The learning from these workshops will further inform recommendations to the NZAB, aiding in advising the federal government on accelerating Canada's progress towards a net-zero future.

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GLOSSARY OF TERMS

Bill of Materials (BOM): The list of materials and quantities in a building that serves for cost reporting. In the context of buildings carbon emissions, it serves as input data for assessment process.

Building Information Models (BIM): Virtual 3D representations of a building and contain information and parameters about its design.

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): Third-party-verified documents report the environmental impacts of a product. They often represent impacts associated with raw materials extraction, products manufacturing, and transportation and distribution (NRC, 2022).

Global warming potential (GWP): A metric of greenhouse gas emissions impact measured relative to the impact of one molecule of carbon dioxide, usually over a 100-year time-frame.

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).

Life Cycle inventory (LCI): A phase of LCA including the data collection and quantification of inputs and outputs associated with a product or process throughout its life cycle (NRC, 2022). Such inputs and outputs include energy, raw materials, other physical inputs, and emissions to air, land, and water (RMI, 2023).

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

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

Product Category Rules (PCR): A set of specific rules, requirements, and guidelines for developing environmental declarations for one or more product categories (NRC, 2022).

Up-Front Carbon: These emissions have already been released into the atmosphere before the building is occupied or begins operation.

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

ABBREVIATIONS

ATHENA | Athena Sustainable Materials Institute

BIM | Building information model

CO_2 | Carbon dioxide

ECCC | Environment and Climate Change Canada

EPD | Environmental product declaration

GHG | Greenhouse gas

GWP | Global warming potential

KG $CO_{2\,EQ}$ | Kilograms of carbon dioxide equivalent

LCA | Life cycle assessment

LCI | Life-cycle inventory

MEP | Mechanical, electrical, and plumbing

PCR | Product category rule

NZAB | Net Zero Advisory Body

NRCan | Natural Resources Canada

NRC | National Research Council Canada

UBC | University of British Columbia

WBLCA | Whole building life cycle assessment

ZBEx | Zero Emission Building Exchange

BACKGROUND

In Canada, buildings rank as the third-largest contributor to the country's total greenhouse gas (GHG) emissions, accounting for 12% of national emissions, following the transportation and oil and gas sectors (ECCC, 2022). However, this total only encompasses operational emissions, and is expected to rise to 18% if embodied carbon emissions are included (NZAB, 2023). Embodied carbon emissions refer to the GHG emissions produced from the energy used for raw material extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials.

The majority of a building's embodied carbon emissions are generated during the production of its materials and components, including raw material extraction and transportation throughout the supply chain, and during the building's construction. Unlike operational carbon emissions, which can be reduced through post-construction efficiency updates, there is very limited opportunity to decrease embodied carbon emissions once the building is constructed.

Until recently, most policies and standards have focused on reducing buildings' operational emissions. However, as buildings become more and more energy-efficient, embodied carbon emissions associated with the manufacture and use of materials are gradually becoming a more significant proportion of total building-related emissions. Between 2022 and 2050, embodied carbon could represent over 90% of a new Canadian building's total emissions (CAGBC, 2021). Embodied carbon in buildings, therefore, needs immediate actions to avoid undermining GHG emissions reductions from energy efficiency.

INTRODUCTION

The UBC'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. Fostering local and regional collaborations and partnerships, the project aims to identify immediate barriers and challenges to implementing embodied carbon policies and actions. Furthermore, it aims to develop solutions such as policy changes, education and training, tools and resources, and governance to advance towards Canada's 2030 and 2050 carbon emissions reduction targets.

Four key objectives of the Pathways project and their corresponding activities are planned as follows:

1. Identify barriers and challenges to the implementation of local and regional policies and regulations to reduce embodied carbon emissions from building materials.

2. Identify and develop potential solutions to urgent challenges through collaborative and applied research projects, building on the collective expertise and experience of government, Industry, and academia.

3. Create pathways or models to pilot and test proof-of-concept policy solutions and analyze their effectiveness, as well as related benefits, constraints, and trade-offs.

4. Create educational and skills development materials and activities around policies and regulatory barriers and solutions, to increase capacity and inform and motivate change in government and Industry.

In order to identify and understand current barriers and challenges, and potential opportunities for solutions, a series of workshops were conducted with representatives from local, provincial, and federal government agencies, industry, and academia. The Challenge-to-Solution Workshops aimed to: (1) explore current challenges of implementing embodied carbon actions and policies in British Columbia, and (2) identify potential short and long-term solutions to key challenges.

The workshops were conducted virtually on Zoom between November 10 and December 5, 2023. They were led by the UBC Sustainability Hub, with assistance from staff at the Athena and ZEBx.

Each workshop focused on one type of challenge, drawn from literature reviews, policy analysis and consultations with building industry professionals and government staff. Specifically:

- Workshop 1 focused on exploring the availability of information and access to low-carbon building products.
- Workshop 2 delved into the integration of building information, emissions assessment tools and project delivery process in whole building.
- Workshop 3 addressed challenges and successes of policies and regulations related to low-carbon products and buildings.

Each workshop was divided into two parts (phases): Phase A focused on (1) refining the broad challenge into a more nuanced description based on the experiences of the workshop participants and (2) identifying a preliminary list of potential solutions, again based on participants' experiences and knowledge. Phase B focused on (3) exploring the scalability and application of these solutions to accelerate adoption and implementation of embodied carbon policy and practices. See Table 1 for the Workshops' topics and structure.

Prior to the workshops, the Pathways project team engaged with multiple stakeholders – including academic researchers, staff from local, provincial and federal government agencies, building industry professionals, and staff from building and climate sector NGOs – to conduct background research on embodied carbon policies and practices. All of these stakeholders and subject matter experts were invited to the workshops. A total of 39 individuals from 21 organizations participated in the three two-part workshops (Appendix I). Participants were provided with a two-page backgrounder before each workshop (Appendix II).

Each workshop in the series followed a structured agenda which included introduction and problem framing, followed by discussion activities, and ending with closing remarks. Discussion activities differed across workshops and included open discussions, breakout sessions, whiteboard interactions, and word clouds. Closing remarks typically included summaries, final discussions, or reflective sessions. After each phase of the workshop, the project team reviewed discussions and highlighted key insights, which were used to inform the topics and activities in the following workshops.

Table 1: Topics and structure of the challenge-to-solution workshop series.

WORKSHOP		TITLE	DATE & TIME (PST)	NO. ATTENDEES
Phase A	1A	Low-carbon Products: Data Availability and Supply Chain	November 10 10.30am - 12pm	17
	2A	Whole Building Data, Assessment Tool, and Workflow	November 15 10.30am - 12pm	16
	3A	Policy & Regulation in Embodied Carbon	November 21 10.30am - 12pm	17
Phase B	1B + 2B	Low-Carbon Buildings and Products Data Flow	November 29 10.30am - 12pm	20
	3B	Successful Policy Adaptation	December 5 10.30am - 12pm	14

WORKSHOP 1A
Low-carbon Products: Data Availability and Supply Chain

Workshop 1A focused on the challenges linked to the accessibility and use of primary carbon emissions data when selecting and procuring low-carbon materials.

Workshop 1A agenda:

1. An overview of the Pathways project and goals for the workshops, and introductions to the project team and workshop participants.

2. Breakout session 1: facilitated discussions on the availability of product data and information between two separate groups. Participants were asked to share how they currently use product data in their professional roles, the challenges they faced in accessing and using the data, and the personal solutions/workarounds developed by them to address these challenges.

3. Breakout session 2: facilitated discussions related to procurement of low-carbon materials between two separate groups. Participants were asked to share the challenges they were facing in procuring low-carbon materials and the personal solutions/workarounds developed by them to address them.

4. A wrap-up discussion sought specific examples from the participants regarding systemic changes they would like to see to address the challenges highlighted and identify who needs to be involved in developing and implementing these solutions.

Workshop 1A had a total of 18 participants: three academic researchers, three staff from local municipalities, one staff from provincial government, two staff from federal agencies, seven building professionals within the building industry, and two staff from building and climate sector NGOs. Throughout the breakout session discussions and wrap-up session, workshop participants shared their individual experiences, informed by their professional experiences, and briefly brainstormed the possible strategies and solutions to improve the ability to design and construct buildings using low-carbon materials.

Workshop 1A discussion summary:

Below is a summary of the Workshop 1A discussions, organized based on the priority given to challenges discussed and their associated solutions.

Challenge 1: Data Availability, Accuracy, and Comparability

Participants noted the limited availability of reliable and accurate emission data and/or Environmental Product Declarations (EPDs) for calculating and comparing carbon emissions of different buildings products. This was an issue for many types of building products, including conventional materials (e.g., concrete, aluminum, and insulation) as well as innovative low-carbon products (e.g., low-carbon concrete). However, it was more pronounced in major structural materials with a higher carbon footprint. Participants noted the limitations due to the proprietary nature of the products and lack of regulations requiring emissions disclosures in supply chains.

In addition to data availability challenges, participants noted issues related to the accuracy and comparability of emissions data and EPDs. Canada does not have national Product Category Rules (PCRs), which would standardize requirements for preparing environmental declarations and reporting on emissions. Currently, product emissions data varies across different regions and manufacturers and is not necessarily up to date. Factors such as country of origin, electricity mix, ingredient composition, manufacturing processes, transportation mode, and date of assessment can cause significant differences in the environmental footprint of building products. Additionally, there are limited tools and expertise in the market for both producing and interpreting emission data for building products.

Existing Solutions: Participants acknowledged that the available product emissions data is usually an estimation, and noted that they try to use credible proxies for gaps in emissions data or EPDs. However, there is little guidance about acceptable alternative data sources or estimates. This approach also tends to be quite project-specific, which limits the transferability of emissions information between projects, due to the high degree of assumptions and variation in proxy calculation methods. Participants also noted that they contact manufacturers directly for product information, where possible, although again, variations in the extent and format of product data limited usefulness and comparability.

Systemic Solutions: Participants generally agreed that the industry would benefit from systematic solutions to address data gap challenges. Recommendations included collaborations between policymakers and industry actors to:

- establish policies, regulations, and guides that could be used to encourage or compel manufacturers to create and update EPD data diligently;

- create material baselines and standards for industry-wide EPDs use, and benchmarking guidance for conducting and comparing product emission data; and
- standardize processes for EPD and emissions data verification, either by government or designated third-party verifiers.

Participants also noted that industry should be encouraged to provide more locally accessible low-carbon product recommendations (e.g., a green materials guide); and more EPDs for non-conventional materials, such as reused or salvage materials.

Challenge 2: Carbon Accounting Tools for Building Products

Participants noted that there are limited carbon accounting or assessment tools that Canadian project teams can use to estimate or compare embodied carbon emissions and other environmental impacts of specific building materials and products. Many of available tools in the market are designed for carbon assessments of entire building. For existing product-level assessment tools, there are disparities between the carbon accounting processes and variations and limitations in their inventories, especially for less conventional products. There is also a lack of transparency into the assessment calculations and background databases that would allow project team to adapt tools and databases to meet their specific building design. Participants note that the use of these tools requires project teams to have specialized, tool-specific skills and knowledge to effectively use them to inform building design decisions and material choices.

Existing Solutions: Participants noted that they develop in-house tools or adapt alternative approaches to using existing tools to address specific questions related to building products.

Systemic Solutions: Participants highlighted the importance of both government and Industry working with tool developers to design and develop enhanced, user-friendly materials, carbon accounting tools, and models with more accurate and transparent background databases. Additionally, policymakers can establish more local and regional standards for the measurement and disclosure of product carbon emissions to be used in databases or in-house assessments.

Challenge 3: Conflicting Priorities Between Carbon Reduction versus Cost Optimization

Participants stated that there could be conflicting priorities between carbon reduction versus cost optimization on building projects. For example, low-carbon products can be challenging to source and procure, and their prices can be higher compared to conventional materials. Project teams using non-conventional materials may need to put additional work into the design and construction phases, which can add to both project costs and schedules. Lastly, engaging in external consultation or devoting staff time to conduct carbon assessment comparisons for different materials alternatives can increase the project cost.

Existing Solutions: Workshop participants did not provide many personal solutions or workarounds to the above challenges and focused more on systematic solutions. One solo solution from an architect was engaging in ongoing discussions with manufacturers and negotiating building products prices to help reduce costs.

Systemic Solutions: Workshop participants noted that additional education and training for building owners or developers is needed to prioritize a low-carbon future, recognize the importance of the environmental impacts from development projects, and create a larger market for low-carbon products and buildings. Regulations and support of Canadian manufacturers by government can also help incentivize or compel change across the entire Industry, increasing the market and reducing the costs of new low-carbon materials.

Challenge 4: Procuring Low-carbon Building Products

Participants noted that there is a growing interest in the use of low embodied carbon building materials. Some jurisdictions in Europe, the U.S. and other places have passed or are developing laws to encourage and expand the procurement of low-carbon building products, however, there are challenges to accelerating the adoption of these new materials. Building owners, developers and project teams all make material choices based on a range of priorities. Reducing the emissions associated with a building is only one priority, and may not be an important one for a specific project's stakeholders. Project teams may select familiar materials and products over new low-carbon ones due to uncertainties, such as associated costs, reliability of supply chain, and availability in the market, despite the potential benefits of a low-carbon alternative.

Limited availability and the comparatively small number of manufacturers producing low-carbon alternatives can also increase procurement timelines and costs due to manufacturing monopolies or simply challenges in meeting growing demand. Limited Canadian suppliers also creates issues, since sourcing low-carbon products from abroad can lead to additional complications and costs associated with imports and transportation (in addition to greater embodied emissions). Lastly, as noted above, lack of credible emissions data makes navigating the procurement decisions more challenging and costlier for project teams and decision-makers.

Systemic Solutions: Participants suggested policymakers can encourage the use of low-carbon materials by offering incentives to buyers for material purchases and to manufacturers to release EPDs for their products. They should also support the development of reliable, localized, and user-friendly guides: (1) for builders to make informed procurement decisions that prioritize materials choices to reduce carbon emissions and cost; and (2) for manufacturers. and suppliers, easy-to-achieve GWP targets for their materials' emissions reduction.

Participants also noted that industry professionals can play a larger role in knowledge and skill building through the development of educational materials that simplify the process of low-carbon procurement and foster discussions with owners and developers on the benefit-costs trade-offs of carbon reduction in materials. As a practical solution from the design team, having a construction manager in both design and procurement teams could help make linkage between building planning, construction, and procurement processes.

WORKSHOP 2A
Whole Building Data, Assessment Tool, and Workflow

Workshop 2A focused on the challenges linked to collecting and using primary data for whole-building carbon emission assessments and integrating carbon assessment tools into the building design and delivery processes and workflow.

Workshop 2A agenda:

1. An overview of the Pathways project and goals for the workshops, introduction of the project team and workshops participants.

2. Breakout session 1: facilitated discussions on the usability of building data and assessment tools between two separate groups. Participants were asked about the challenges they were facing in using building information and existing tools to assess building-scale carbon emissions and the personal solutions/workarounds developed by them to address these challenges.

3. Breakout session 2: facilitated discussions on the integration of carbon assessment into workflow between two separate groups. Participants were asked to share the challenges they were facing in integrating assessment results and tools with the process of designing, constructing, and operating a building, and the personal solutions or workarounds developed by them to address the challenges.

4. A wrap-up discussion sought specific examples from the participants regarding systemic changes they would like to see to address the challenges highlighted and who needs to be involved in developing and implementing these solutions.

The focus of Workshop 2A was to understand and refine challenges linked to collecting and using primary emissions data for whole-building assessment and workflow improvement. Throughout the breakout sessions discussions, participants shared their individual experiences related to use of building-related data and tools to conduct a whole building embodied carbon assessment and integrating these tools and results into design, construction, and operation workflow.Workshop 2A had a total of 16 participants: three academic researchers, three staff from local municipalities, one staff from provincial government, three staff from federal agencies, five building professionals, and one staff from building and climate sector NGOs. Throughout these discussions, participants shared their practical solutions from their experiences to navigate some of the challenges. Further, the workshop explored potential systematic solutions that industry leaders and policymakers would like to recommend supporting reduction in building sector embodied carbon emissions.

Workshop 2A Discussion Summary

Below is a summary of the Workshop 2A discussions, organized based on the priority given to challenges discussed and their associated solutions.

Challenge 1: Data Availability and WBLCA Tools

Participants noted challenges in using building-scale life cycle assessment tools to estimate embodied carbon

emission for whole buildings, due to the unavailability and inaccuracy of product-scale data. Each LCA tool has its own material and product database, and the data used for assessment provide generic information and results which may not be applicable to local contexts or necessarily accurate for the specific building design. Some tools allow users to input materials' embodied carbon emissions data manually, however, product-level emissions data usually does not include information on all the life cycle stages needed for a whole building assessment. Also, there is limited to no data available some building components, such as MEP equipment and furniture.

In addition, participants noted that while there are many WBLCA tools available in the market for impact assessment at different stages of design; often their results are not comparable and the models are non- interchangeable between software platforms. These variations can lead to additional challenges. For example, project teams may be required to use different tools for a project at different levels of development or when assessing different level of details. However, aggregated results from assessments conducted on multiple tools may not be accurate and comparable. A similar challenge can be encountered during portfolio or city-wide assessments.

Existing Solutions: Some of the participants shared that such challenges are addressed by firms developing in-house tools for quick analysis and comparison of different models during the early stages of their building design. These in-house tools were typically developed over time and tailored to the specific types of projects, locations and products commonly used by that firm. They helped firms address design questions quickly and determine the necessity of conducted a more comprehensive WBLCA. However, the in-house approach requires firms to hire professionals to develop and maintain the tools.

Systemic Solutions: Workshop participants noted that policymakers can play a big role in addressing many of the above challenges by creating codes and standards to streamline and standardize the collection of building-scale embodied carbon emissions data. Tool providers should collaborate with industry to enable manual input of new product data or EPDs, customization of other building elements (such as MEP equipment) or differentiating retrofits and renovations. All parties should work together towards the development of a standardized format that is compatible and exchangeable across platforms.

Challenge 2: Integration of Building-scale LCA into Design and Construction Workflow

Participants noted that current LCA tools and databases do not necessarily align with the design tools and workflow used in the delivery of a building project. For example, in the early design phase, members of project teams may work more independently on their specific scope rather than on an integrated model. These early models are often developed in different software, with different design assumptions and parameters, and many do not have the level of detail needed for an LCA tool. If project teams conduct early carbon emission estimates, they cannot be directly translated to more detailed LCAs as the project evolves. Generally, LCAs and the models created through the tools were seen as additional scopes of work beyond the primary building design process, and which required additional time and specialized expertise along with associated project costs.

Existing Solutions: Participants reported using early design analytical tools or in-house calculations for quick emissions estimations to inform broad design decisions within their scope of work. However, new LCA models still had to be created from scratch at later stages of design.

Systemic Solutions: Participants noted that the solution to this challenge requires systematic interventions by the multiple levels of government and by industry leaders. Key solutions discussed included:

- An NGO representative noted that government should take the lead in coordinating policy around LCA models and reports, to encourage consistent approaches between different regions and prevent duplicative efforts. The federal government might consider piloting strategies for integration of embodied carbon assessment in design and development processes such as an embodied carbon step code.

- Participants noted that given that building owners are the ultimate decision-makers, federal and provincial governments need to raise awareness and develop policies that incorporate the external cost of embodied carbon assessments into building design and construction processes and cost estimates.

- An industry professional recommended that municipalities (or other permitting organizations) standardize LCA integration process during different building stages and/or material-specific emissions baselines as well as providing resources and guidance to support design decision-making, such as templates and guidelines.

- Lastly, there was a general agreement among participants that tool providers should collaborate with policymakers and industry practitioners to enhance accessibility and interoperability of data, and improve alignment of decisions for reducing embodied carbon emissions with building design workflows.

WORKSHOP 3A
Policy and Regulation in Embodied Carbon

Workshop 3A builds upon the discussions in Workshops 1A and 2A, addressing the challenges involved in developing and implementing policies and regulations to mainstream low-embodied carbon products and buildings.

Workshop 3A agenda:

1. An overview of the Pathways project and goals for the workshops, introduction of the project team and workshops participants..

2. Breakout session 1: facilitated discussions on the policy and regulatory challenges at different scales between two separate groups. Participants were asked to share the policy and regulatory challenges impeding the adoption of low-embodied carbon products and buildings, as well as the challenges connected to different levels of government and/or industry sectors.

3. This was followed by combined follow-up discussion between both groups on some of the key challenges identified in each breakout session.

4. Breakout session 2: facilitated discussions on potential systematic solutions to the above challenges or successful policies between two separate groups. Participants were asked to share about the potential short-term and long-term policy solutions or examples of successful policies that should be expanded or adapted.

5. This was followed by a wrap-up session to explicitly connect potential policy solutions to specific challenges and highlight important features of successful policies.

Workshop 3A had a total of 20 participants: two academic researchers, two representatives from building and climate sectors NGOs, nine building professionals, one staff from federal government agency, two staff from local government agency and four staff from provincial government agency. Participants drew on their professional expertise and knowledge to highlight policy and regulatory approaches that could be adapted and expanded to mainstream low-embodied carbon products and buildings. The timeframe for implementing the identified approaches was discussed in Workshop 3B.

Workshop 3A Discussion Summary

Below is a summary of the workshop 3A discussions, organized based on the priority given to challenges discussed and their associated systematic solutions that could address the challenge.

Challenge 1: Balancing Low-carbon Building Priorities and other Building Policies

Participants unanimously noted that reducing embodied carbon through LCAs or material choices is only part of creating low-carbon buildings and materials. Other considerations include retrofit strategies, green construction, circular economy practices, low-carbon manufacturing, and green procurement. Additionally, they noted that while some policies complement each other, others may conflict. For example, policies and regulations that promote resiliency aspects, such as fire resistance in buildings, potentially incorporate measures that increase the quantity of building materials and their embodied carbon levels.

Systemic Solutions: Participants simply noted that policies addressing embodied carbon need to be considered and included in other planning and development policies. For example, explicit embodied carbon regulations related to new construction could be combined with policies supporting building and material reuse, for a more comprehensive approach to reducing building scale emissions.

Challenge 2: Limited Regulations on Data Disclosures for Building-scale Emission Assessments

Some participants noted that there is a challenge in the available ways that embodied carbon emissions can assessed and regulated. Generally, local government is limited to regulating emissions within their legal jurisdiction (e.g. territorial-based inventories), but embodied carbon emissions assessments require data from long supply chains (e.g. material-based inventory) which cross multiple territories on local, regional and international scales. This poses a fundamental challenge for standardization of emissions data, reporting and assessment, which requires involvement from higher tiers of government with broader authority.

Systemic Solutions: Government representatives suggested local governments focus on developing mandatory building-scale emission disclosures as a crucial first step in collecting consistent data, with improved accuracy over time as data and tools develop. This local disclosure data can help to inform standardization and benchmarks in aggregate by higher tiers of government. Such standardizations and benchmarks could then be customized for different geographical locations, while materials less affected by geographical variances can have a material-based benchmark. They proposed adding a localized addendum to the NRC's WBLCA guidelines for creating local mandatory disclosure guide.

Challenge 3: Limited Guidance on Building-Scale Emissions Assessment during Different Stages in Building Design and Development

Participants from the industry confirmed that there is little policy guidance or regulatory standardization on how to conduct or report on whole-building LCA and carbon assessments, specially the variations in data and modelling at different stages of buildings' development.

Systemic Solutions: Participants suggested that there needs to be more resources for both industry and policymakers to create consistent and standard embodied carbon emissions reporting at different stages of building development. Participants noted the City of Vancouver's Embodied Carbon Guide v.1 as one of the few by-laws in Canada and which could be used as a blueprint for others, but stated that a consistent regional approach would benefit both the building industry and smaller jurisdictions. Additionally, some participants suggested local governments to shift towards enabling Building Integrated Modeling (BIM) digital permitting processes and BIM-based estimators, which could potentially help to expedite LCAs and carbon accounting.

Challenge 4: Absence of Reliable Approach for Whole Building LCAs Baselines

Participants raised the issue that even when there are existing embodied carbon policies , most use a comparative prescriptive approach (i.e., percentage reduction against theoretical buildings) for carbon emissions measurements and reductions assessments. Although generally recognized as a good first step, participants noted the comparative approach does not have a consistent baseline to measure performance against. Lack of a standard baseline makes it more challenging to assess actual progress in reaching emissions reductions targets, to set the targets themselves, to compare buildings to determine effective design approaches or to adapt to regional climate or economic variations.

Systemic Solutions: Participants suggested a stepped approach to pave the way for defining reliable methodologies for LCA baselines, starting with a mandatory reporting of building-level emissions and percentage reduction targets that can be used to establish standard baselines prior to increasing performance targets in incremental steps. Participants recognize that continuous dialogue between policy makers and building industry would be critical to this approach, which would need to involved multiple tiers of government.

Challenge 5: Insufficient Time to Assess Policies Effectiveness

Participants agreed that the true impact and outcomes of recent embodied carbon policies remain uncertain because not enough time has passed since they were implemented. Additionally, these policy are not yet widespread so the extent of their potential impact is limited. As these polices become more established and/or more broadly applied across Canada, there may be challenges with industry adoption or complications with legal and trade issues related to procurement. They admitted that policies play a substantial role in managing embodied carbon emissions, particularly within procurement policy, where potential risks in legal and trade aspects may emerge; however, the effectiveness of these policies is contingent on finding the right balance between end-user involvement and policy development. Regarding this challenge, no systematic solutions were discussed.

Systemic Solutions: Regarding this challenge, no systematic solutions were discussed. However, participants noted that for now, learning from experience is critical both in terms of how policies are developed and implemented and ways that the industry complies with the regulations and reporting. Participants cited positive impacts observed from other policy areas, such as the operational carbon emissions, as models.

In closing remarks, participants shared their views on the most critical features for successful embodied carbon regulation. Participants noted the importance of accessible user-friendly tools and processes, such as digital permitting, BIM, and LCA tools, along with standards for consistency. As many decisions are still cost-driven, participants emphasized

the association of dollar values with the impact of embodied carbon emissions will help ensure successful regulation. Lastly, participants considered the provision of financial, technical, and educational support critical so that both government and industry are equipped with the necessary resources and knowledge to develop and comply with embodied carbon regulations.

WORKSHOP 1B+2B
Low-carbon Buildings and Products Data Flow

Workshop 1B+2B focused on refining systematic solutions to address challenges at the intersection of product and building-scale embodied carbon identified by participants throughout Workshop 1A and Workshop 2B (Figure 1).

The discussions in Workshops 1A and 2A were broad, but generally addressed major challenges around data availability and usability in decision making, and identified similar types of potential solutions across both the product and building scales. These discussions were streamlined into a single workshop, Workshop 1B+2B (Low Carbon Building Product Data Flow) focused on actions to improve the availability and usability of products and buildings data.

Workshop 1B+2B agenda:

1. An overview of the Pathways project, goals for the workshop, and introduction of the project team and the workshop participants.

2. Activity 1: group discussion with a whiteboard activity where participants drew a roadmap of actions to improve the availability and usability of material and product emissions data. Participants were asked what potential actions could be taken by different scales of government and the building/manufacturing industry to improve the availability and usability of material and product emissions data in building-scale carbon assessments.

3. Follow-up discussion on some of the key solutions.

4. Activity 2: Group discussion with a second whiteboard activity where participants drew a policy and practical solutions roadmap to improve the availability and usability of whole building emissions data. Participants were asked what potential actions could be taken by different scales of government and building/manufacturing industry to improve the availability and usability of whole building emissions data in broader portfolios and jurisdictions.

5. Wrap-up discussion to highlight some of the most important actions.

Workshop 1B+2B had a total of 17 participants: three academic researchers, two representatives from building and climate sector NGOs, nine building professionals, one staff from a federal government agency, and two staff from local government agencies.and product data availability, as well as highlights for key priorities.

Activity 1: Roadmap of Actions to Improve the Availability of Product Emissions Data in Building-Scale Carbon Assessments

The first group activity was conducted on a whiteboard via the Zoom platform. Participants were asked about the actions that could be taken to improve the availability and usability of product emissions data in whole-building-scale carbon assessments. This question aimed to map systematic existing and future policy and practical solutions that could be taken by government and/or industry to address the challenge of product data availability. Table 2 compiles existing, short-term, and long-term actions suggested by participants for different government and building industry scales in response to our question.

Figure 1: Focus of Workshop 1B+2B.

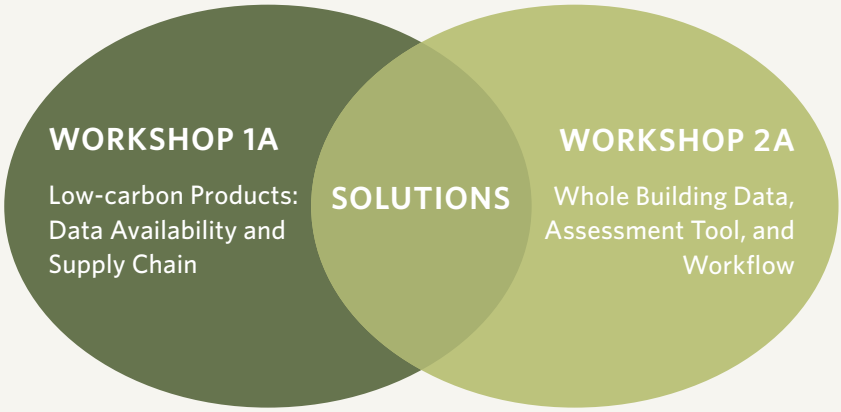


Table 2: A roadmap detailing existing, short-term, and long-term actions that were taken and that can be taken by the government and building industry to improve the availability of product emissions data in building-scale carbon assessments.

Guiding Question: What are potential actions that could be taken to improve the availability and usability of material and product emissions data in building-scale carbon assessments?

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Government	• Escalate the price on carbon • Standardize language between builders and LCA practitioners • NRC continues to pay for industry LCAs and continue creating a national LCI database • Subsidize the supply and use of low-carbon materials • Develop methodology to expand LCA scope into interior finishes (less data on MEP, but many EPDs available for finishes) • Conduct location-specific cost studies in Canada • Ensure availability of free WBLCA tool(s) • Put more emphasis on bringing lower carbon products into building official/inspection training across the country • Ensure that new building prototypes that get developed in British Colombia respond to recent planning changes (to increase housing) and use lower carbon materials (that this lens be prioritized) • Higher tier government offer funding for more localized case studies to help collect data and inform their policies that will likely not be published until 2030	• Mandate the disclosure of emissions by manufacturers for materials with significant impacts, such as concrete and steel • Municipal governments mandate LCAs for new developments • Mandate EPDs from manufacturers (more product-specific EPDs than industry average) • Revise the federal approach to procurement. The current method is limited in its ability to identify products/manufacturers that have product-specific EPDs, as consultants are not permitted to identify products/manufacturers. As well, there are no incentives or rewards for leading manufacturers in the industry • Government fills big data gaps that no one industry can do (e.g., construction stage data) • Establish a national BIM mandate • Government incentives for optional "above and beyond" Embodied Carbon design considerations • Create whole-building LCA benchmarking infrastructure • Other Incentives (e.g. disclosure) • Integrate embodied emissions into emission inventories and policies (i.e., carbon tax/carbon caps, building codes, rezoning requirements, etc.)	• Set ambitious WBLCA targets for the next 10-20 years • Set carbon taxation based on actual costs (social/env) of emissions - or simply absolute regulations on carbon pollution • Develop code and standards relating to reclaimed materials, allowing people to start manufacturing products like CLT from reclaimed stick framing • Attach full value chain carbon costs to new construction, and the resulting revenue is directed to incentives for building retention; less new construction is the only guaranteed way to reduce embodied carbon

Table 2 Continued.

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Government	• Continue to develop simple data disclosure templates to facilitate data collection	• Federal government provides financial support for Canadian manufacturers to develop product-specific EPDs. As well as prioritization on selecting on North American and Canadian manufacturers. Often what is happening is cost is still the main deciding factor on product selection and offshore dumping of materials continues to happen due to low cost • Integrate artificial intelligence (AI) for policy and reporting • Develop Master Specification language that provides the industry standardized language on procuring products with 3rd party verified material transparency such as EPDs • Create and enforce guidance for ISO compliance on use of EPDs, especially in context of simplified EPD access tools • Develop standard RFP language so public sector can ask for LCA / low embodied carbon solutions	
Government & Industry Collaboratively	• Improve cross country coordination regarding new lower carbon products and their integration into building codes - setting up one committee	• Industry and/or government create standards for information included in EPD, PCRS and other documentation used by design teams • Industry and Government alignment for a blueprint for ECR Policy • Access to one unified (ideally govt run) product material database	• Materials/specs auto-selected by a set of vetted common industry standards for firms that want to just hit the "net zero" button (that auto considers price, distance, durability, availability)

Table 2 Continued.

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Government & Industry Collaboratively		• Network and learning/sharing space for all stakeholders	
Industry	• Manufacturer and/or suppliers voluntarily disclose their product emission data to enhance assessment accuracy in buildings • CRREM to plan and prioritize low carbon renovations and retrofits - determine the ROI between now and 2050 • Accurate auto calculation of material quantity from BIM model • Determining what information can be shared by all building supply stores in a way that doesn't remove competitive advantage but also helps government build policy etc.	• Super simple interface tool with averaged GWP per basic materials. Should be easy enough for any technical level (think Payette Kaleidoscope) • Simplified EPD sorting process within LCA software(s) • Common industry software inputs (general vs specific material EPDs) • Common framework for LCA software so assumptions within software is not widely different from each other • Have built-in EPD product info into BIM software without plug-in or high learning curve • Create easy to use EC cheat sheet and tools for high-level evaluations at the start of projects • Audit WBLCA to review the baselines or materials that are selected. As sometimes incorrect products or products not available in Canada get selected which isn't entirely reflective of what is market viable	• Develop/utilize digital building logbooks to capture and retain material information through building lifecycle • Improve the creation and use of as-built WBLCAs • Integrate embodied carbon with operational carbon modelling and reporting

Throughout the activity, participants engaged in a parallel discussion on which actions they saw as particularly important or urgent. The highlights from the discussion are summarized below.

Develop consistent industry-wide language at the national level. Industry representatives reiterated their struggle to produce, obtain, and understand required carbon emission data due to fragmented and diverse terminology. They highlighted the role of higher-tier government agencies in setting clear rules and adopting consistent languages that benefit all building stakeholders, particularly smaller builders and local municipalities.

Develop simplified and approachable tools and software platforms. Some participants (particularly architects) noted an urgent need for a user-friendly software to streamline the handling of emissions data and growing number of EPDs for manufacturers and industry practitioners. All participants agreed that this solution could ease companies' workload, particularly small businesses that may not have in-house experts.

Pilot innovative solutions across municipalities to scale impact. A local government staff suggested launching pilot projects to test innovative solutions at multiple governmental levels. They noted the capacity of these projects to lay the foundation for broader market development, starting at the local level and expanding to provincial and national levels.

Continue ongoing efforts, such as those led by the National Research Council (NRC). An industry representative highlighted that the federal government's engagement with the NRC could benefit small and medium-sized developers by introducing incentive programs. The participant added that the government can support building projects from early design phases through NRC and influence the trade associations, which often operate at a national level.

Leverage strength of Building Information Modelling (BIM) platforms. A building consultant pointed out that Canada is the only country among G7 nations without a mandate for the use of an advanced BIM system. The participant suggested that the federal government can collaborate with software developers to integrate EPDs into BIM software and make BIM adoption mandatory for the building industry. This Could benefit industry practitioners through improved automation of carbon emission assessments.

Develop codes and standards, and set realistic performance targets. Participants agreed that the priority is to establish embodied carbon standards and set ambitious targets, and to incorporate all of this into the national building code. Participants emphasized the most critical components are consistent data and accessible tools.

Activity 2: Roadmap of actions to improve the availability and usability of whole building emissions data in broader portfolios and jurisdictions

The second group activity was conducted as another Zoom whiteboard session and asked participants about actions that could be taken to improve the availability and usability of whole-building emissions data across broader portfolios and jurisdictions (e.g. collections of buildings). This question aimed to map existing and future policy and practical solutions that could be taken by government and/or industry to address the challenge of availability and accuracy of building-scale emissions data. Table 3 compiles existing, short-term, and long-term actions suggested by participants for different government and building industry scales in response to our question.

*Table 3: A roadmap detailing existing, short-term, and long-term actions that were taken and that can be taken by the government and building industry to improve the availability of whole building emissions data in broader portfolios and jurisdictions. (*solutions not discussed are marked with "not indicated.")*

Guiding Question: What are potential actions that could be taken to improve the availability and usability of whole building emissions data in broader portfolios and jurisdictions?

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Government	▪ Municipalities or provinces develop standardized reporting guidelines and templates for emissions assessment of different building types in their jurisdictions ▪ Use data to indicate coordinated policy pathways at different levels of government ▪ Align embodied carbon data with operational emission data ▪ Build more provincial coordination re: consumption-based emissions. Currently, municipalities are predominantly focused on emission tracking based on territorial-based inventories (wouldn't necessarily be assisted by lower embodied carbon policies) ▪ Set Operating and embodied carbon emission targets for buildings ▪ Require operational emissions within LCA scope ▪ Require third-party verification to increase comparability ▪ Set archetype studies to illustrate design strategies for average buildings to improve	▪ Prioritize standardization, harmonization, and data gap filling in the whole-building LCA, which must come first before even considering reporting, etc. ▪ Initiate open databases showing emissions from different buildings based on building permit submissions etc., at city levels first, then move on to wider regions later ▪ Enhance disclosure regulations to include operating and embodied carbon ▪ Provide /develop sample baseline assumptions for typical building typologies ▪ Mandate material carbon reporting through EPD format ▪ Green procurement, starting from Government-owned properties	▪ Government implements databases and other systems for consistent tracking and reporting of building industry embodied emissions ▪ Set firm/portfolio level emissions targets, allowing companies to go more aggressively on some projects to offset projects that have little opportunity/ additional restrictions ▪ Align EC policies and goals with emerging work to advance a circular built environment and ISO 323
Government & Industry Collaboratively	▪ Building industry and/or government develop standards for embodied carbon baselines and performance targets	▪ Develop disclosure databases like Building Benchmark BC but for embodied carbon	*Not indicated

Table 3 Continued.

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Government & Industry Collaboratively		• Mandate Modular and prefab builders to provide embodied carbon information to their standardized products • Provide prototype benchmark over built benchmark libraries • Validate data (peer review)	
Industry	• Industry leaders to share their in-house practices in building emissions modeling and assessment to improve broader knowledge and skills • Portfolio managers and owners can use CRREM to plan their energy and O&E carbon reduction investments and evaluate the risks	• Improve open-source tools/databases with 3rd party verifiers • Add O&E carbon benchmarking to GRESB • Implement Industry standardized approach to reporting data and baselines • Certainty or clarity around the building benchmarks that exist, such as the City of Vancouver rezoning submissions • Add standard embodied carbon criteria/data to preapproved designs and patterns (e.g., the new Pt 9 preapproved small building designs) • Benchmark verification on process, dataset, and material selection accuracy • Promote education on international standards and how to use them effectively • Translate learning from operational emission tracking and reporting • Researchers to run case studies for developers on the business case and value proposition of a low embodied carbon • Improve efficiency in construction processes aligned with a baseline	• Owners create building materials passports to gather data on buildings' constituents -material transparency

Throughout the second whiteboard activity, participants engaged in a parallel discussion on key actions to address the challenge. We have summarized The highlights from the discussion are summarized below.

Establish standardized reporting guide. An industry representative highlighted the importance of establishing standardized guidelines for the reporting of whole building emissions across various building types. The participant noted that these guides could offer clear instructions for details related to WBLCAs (e.g., tools, methods, scope, and assumptions), promoting consistency and comparability of results.

Incentivize building industry to address data uncertainty and introduce carbon fee. A building consultant noted that different government levels could incentivize the construction industry to prioritize buildings with lower embodied carbon and address the uncertainties around emissions data. In addition, the participant proposed that introducing carbon fees on new constructions could further promote data production and development across the building industry.

Update green procurement policies. An academic researcher highlighted the government's role in updating the green procurement policies and enforcing sustainable procurement. They suggested that the process could be initiated with government-owned properties and scaled further to the construction sector.

Prioritize high-quality EPDs and navigate data uncertainty. A building industry representative emphasized the importance of prioritizing the generation of high-quality building product emissions data and EPDs before the government mandates building LCAs. Another participant agreed and added that it is necessary to recognize a certain degree of uncertainty to accelerate the progress in collecting data on whole-building emissions.early design phases through NRC and influence the trade associations, which often operate at a national level.

Create/Pilot local case studies. An architect emphasized the necessity for pilot projects in the building industry to demonstrate market advantages, risk mitigation, and Return on Investment (ROI) associated with low-carbon construction approaches and the value proposition of low embodied carbon buildings.

Educate and value reduced embodied carbon in buildings. A B.C. NGO representative proposed seeking support from professional training institutes and accreditation bodies to create educational materials and educate non-expert stakeholders on low-carbon building knowledge and practices. The participant added that assigning "value" to reduced embodied carbon in healthy buildings, much like emphasis on "comfort" in energy-efficient buildings, can encourage commitment to low-carbon buildings among developers and builders.

WORKSHOP 3B
Successful Policy Adaptation

Workshop 3B focused on identifying policies that successfully addressed challenges to low-carbon buildings and products and how to adapt and expand them more effectively. The discussions explored intersections between various policy domains and discussed ways to synchronize these parallel efforts.

Workshop 3B agenda:

1. An overview of the Pathways project and goals for the workshops, introduction of the project team and workshop participants.

2. Activity 1: group discussion with a whiteboard activity where participants mapped successful policies and regulations. Participants were asked what the current successful policies and regulations are at the local, provincial, and federal government levels.

3. Follow-up discussion on some of the policies and how they could be adapted or expanded to ensure short-term and long-term success.

4. Activity 2: group discussion with a word cloud activity where participants raised the policy domains that may intersect with embodied carbon policies. Participants were asked about the anticipated intersections between embodied carbon policies and other policy domains across various government levels.

5. Wrap-up discussion to highlight the most mentioned intersections and how to strategically coordinate and align efforts across various government levels.

Workshop 3B had a total of 14 participants: one academic researcher, one representative from a building and climate sectors NGO, eight building professionals, two staff from the federal government agencies, one staff from the B.C. government, and one staff from a B.C. local municipality.

Workshop 3B Discussion Summary

Below are lists of successful current policies and their expansion or adaptation strategies as identified by workshop participants, including intersections with embodied carbon policies and efforts to align strategies across government levels.

Activity 1: Successful Cases of Current Policies and Their Adaption or Expansion Strategies

The first group activity was a whiteboard session via the Zoom platform. Participants were asked to note current successful policies and regulations at the local, provincial, and federal government levels. Additionally, participants discussed how these examples of successful policies could be adapted or expanded to ensure short-term and long-term success. Table 4 contains the examples of existing, short-term, and long-term successful policies at different government levels identified by participants during Activity 1.

*Table 4: A list of existing, short term and long-term successful policies implemented at different government levels (*policies not mentioned are marked with "not indicated.")*

Guiding Question: What are the current successful policies and regulations at the local, provincial, and federal government levels?

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Federal	• NRC WBLCA guidelines • Standard on Embodied Carbon in Construction • Greening Government Strategy • Federal's incentive program on EPD generation • USA GSA Inflation Reduction Act	• Part 9 in Embodied Carbon Reduction Policy • Government of Canada Buy Clean Strategy	• Net Zero Emissions by 2050
Provincial	• BC Mass Timber Action Plan • California's CALGreen Sustainable Construction • New Jersey's Low Embodied Carbon Concrete Leadership Act	• BC Low-Carbon Buildings Material Strategy • BC Provincial public sector organization (PSO) building certification requirements • BC Energy Step Code and Zero Carbon Step Code	• Net Zero Emissions by 2050
Local Government	• City of Vancouver embodied carbon bylaw in VBBL (refer to the city of Vancouver embodied carbon guide, v1) • UBC embodied carbon reporting requirement for new residential construction (REAP) • Peel Region's Sustainable New Communities Program awards • Toronto Green Standard's optional embodied performance tiers • Langford Low Carbon Concrete policy • Nelson's Free Embodied Carbon Consultation for Part 9 home projects • Saanich's City Design Guidelines • UBC institutional embodied carbon policy using UBC WBLCA Guidelines • District of North Vancouver's Climate Ready Rezoning Policy • City of Port Moody's Sustainability Report Card • UBC whole building life cycle assessment guidelines V1.1	• City of Vancouver embodied carbon bylaw in VBBL (refer to the city of Vancouver embodied carbon guide, v1) • City of Vancouver's target of 40% reduction by 2030	• World Green Building Council to set Net Zero Embodied Carbon goal for 2050 • UBC Climate Action Plan to target 50% reduction in building embodied carbon over baseline

Throughout this activity, participants were encouraged to discuss and expand on the policy examples on the whiteboard and how they could be adapted or expanded. Participants discussed these policies at three different levels:

- Product-scale policies: policies governing carbon emissions from building products and manufacturing.
- Building-scale policies: policies directly governing carbon emissions from whole building design and construction.
- Comprehensive policies: policies with a broader range, including community planning, construction codes (e.g., plumbing, fire, etc.), and other related aspects.

Product-scale Policies:

A federal government participant noted the potential for leveraging the procurement of construction materials with major carbon emissions, such as concrete and steel, through the Canada's Industrial Deep Decarbonization Initiative (IDDI) Green Public Procurement Pledge. This pledge was announced on December 5, 2023, and through it, Canada adopted a timebound commitment to the procurement of low-carbon steel and concrete, development of carbon accounting standards and definitions for low-to-near-zero carbon construction materials, and harmonization of EPD product category rules.

Participants highlighted that Canada currently lacks support for manufacturers in assessing or reporting their products' carbon emissions and that government could learn from policies and incentive programs available in other countries. Suggestions included US actions:

- US Inflation Reduction Act 2022, which offers grants, technical assistance, and tools (such as carbon labeling) to assist US manufacturers in using, measuring, reporting, and reducing levels of embodied carbon and other greenhouse gas emissions for their products.
- Additional federal actions by the Biden-Harris Administration to support clean manufacturing practices with investments in training, incentives, and technology development for supporting the industrial sector and manufacturing low-carbon materials.

Building-scale Policies:

Participants noted the province of British Columbia contain multiple examples of successful local government policies for the assessment of building embodied carbon emissions of Part 3 buildings. These policies could be used as models for other municipalities, who could adapt their instructions to the local needs and contexts. These policies include:

- City of Vancouver's Embodied Carbon Guidelines, a set of instructions for the building industry to comply with the City of Vancouver's new building Bylaw for carbon assessment in new construction.
- District of North Vancouver's Climate Ready Rezoning Policy, a set of requirements to report new building projects' emissions before construction in the North Vancouver district.
- City of Port Moody's Sustainability Report Card, a building checklist for new projects in Port Moody to report embodied emissions and propose strategies to reduce impacts.

Participants also noted that the 2030 National Building Code of Canada (NBC) promises to have embodied carbon requirements, and NRC is currently piloting projects aligned with this target.

Comprehensive Policies:

A participant from local government noted the potential for prioritizing embodied carbon emissions reductions in the Official Community Plans (OCP) for local governments, a statement of objectives and policies that guide regional districts and municipalities for district planning and land management decisions. OCPs are required to be renewed periodically, and most in British Columbia will be updated within the next few years.

An NGO participant noted the signing of Construction Codes Reconciliation Agreement by the province of British Colombia. The agreement is set to harmonize construction codes (i.e., building, plumbing, fire, etc.) across Canadian provinces and is a platform for B.C. to participate in the annual public review of proposed changes to the National Model Codes. The participant suggested that B.C. can take this opportunity to advocate for the integration of embodied carbon measures in construction materials and processes.

Additional adaptation and expansion strategies that were documented on the whiteboard but not discussed here during Zoom session are compiled in Table 5.

*Table 5: Policy adaptation and expansion strategies that were not discussed in Zoom session (*Strategies not mentioned are marked with "Not indicated.")*

Guiding Question: How can these policies be adapted or expanded to ensure success in both short term and long term?

	EXISTING	SHORT TERM (2024 - 2030)	LONG TERM (BEYOND 2030)
Federal	*Not indicated	• NRC Guideline to increase reduction target and benchmarking • Guidelines to expand and include commodity products beyond structural elements	*Not indicated
Provincial	• Ensure Climate Action Secretariat's circular economy team is aligned with BSSB & Office of Mass Timber	• Integrating embodied carbon consideration into urban design guidelines	*Not indicated.
Local Government	• Require LCAs at Rezoning Vancouver	• UBC REAP to introduce EC mandatory requirements for neighborhoods	• Embodied Carbon Strategy (Appendix K of City of Vancouver Climate Emergency Action Plan) states intention to enable an even more circular economy in the future (e.g., Design for Disassembly)

Activity 2 (Part 1): Intersections between Embodied Carbon Policies and Other Policy Domains

The second group discussion activity was in two parts: an online word cloud and associated discussion. Participants were asked to identify what they saw as the anticipated intersections between embodied carbon policies and other policy topics and domains across various levels of government . Figure 2 shows the resulting word cloud.

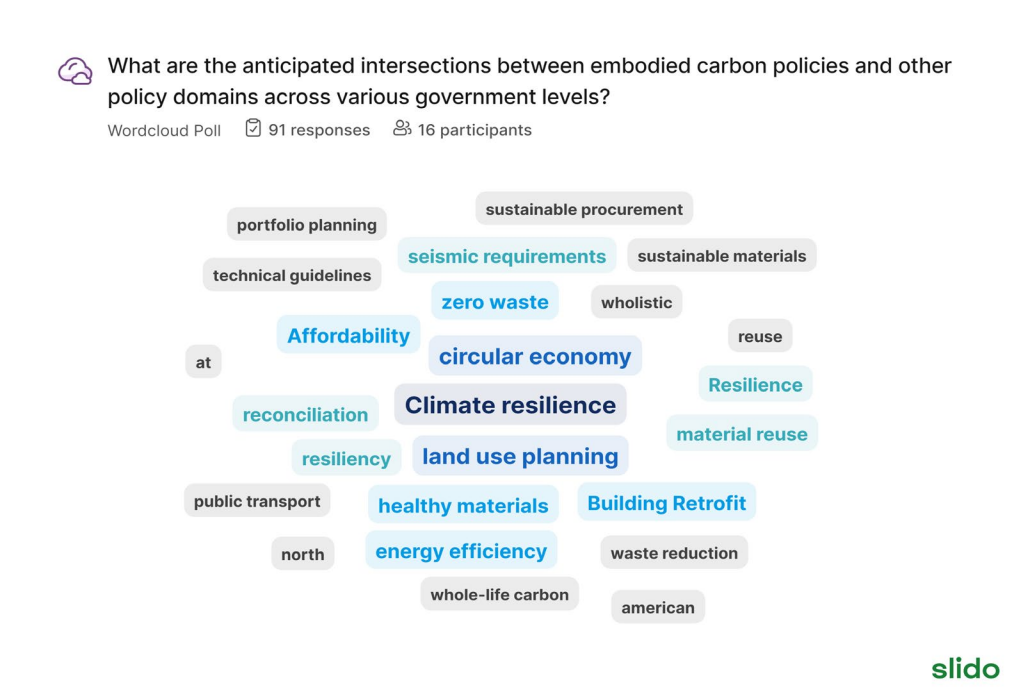
The participants engaged in parallel discussions to highlight areas with strong intersections, as follows:

Policies in the circular economy. An architect stated that the circular economy policy and planning for end-of-life scenarios could yield significant embodied carbon reduction and waste reduction.

Policies in zero waste or deconstruction. A local government representative stated that the goals of minimizing waste from construction, renovation, and demolition activities and reducing embodied carbon emissions are parallel paths toward sustainability in the building sector. By integrating these goals, building practices can be optimized that not only minimize building embodied carbon but also consider the end-of-life phase, ensuring materials are repurposed rather than discarded.

Expanding on existing initiatives. An LCA specialist shared information on mindful MATERIALS, an organization that focuses on synthesizing policies across various government levels and certification policies into 50 different metrics. They aim to avoid a single focus on embodied carbon and promote a holistic approach to policy considerations.

Figure 2: Workshop 3B, Activity 2, Word Cloud: What are the anticipated intersections between embodied carbon policies and other policy domains across various government levels.



Activity 2 (part 2): Strategy to Coordinate and Align Efforts Across Various Government Levels

As concluding discussion for Workshop 3B, participants shared insights on how to strategically coordinate and align efforts across various government levels. The key strategies discussed by participants included:

Address variation in terminology among government and industry. An NGO representative highlighted one significant challenge for the coordination across different departments within government is the diversity of industry-specific language and terminology. The participant noted that a standardized language around embodied carbon emissions between policies, industry, and multi-governmental levels is essential to facilitate effective collaboration.

Address education and skill development gaps in government and industry. Participants emphasized the need for improved education and skill development in the building industry and at all levels of government to understand embodied carbon concepts and its assessment methods. All participants agreed the importance of coordination and knowledge sharing between government and industry, and the need to align action at different government levels. Solutions discussed included:

- Requirements for specific skill sets or accreditations, and incorporation of these requirements into emissions reporting submittals to incentivize the building industry to develop more expertise in embodied carbon assessments.
- Valuing new skills within the industry through compensation, awarding of contracts and other opportunities.
- Government modeling best practices through procurement and project delivery requirements and agreements on their own projects to demonstrate value to the industry and build a market for skills in both government staff and industry practitioners.

Between November 10 and December 5, 2023, UBC's "Pathways to Net-zero Embodied Carbon in Buildings" project team organized a series of Challenge-to-Solution Workshops focused on challenges and solutions in implementing embodied carbon into building policy. Workshop participants represented 21 organizations, including academia, NGOs, building professionals, and government agencies.

Summary of Insights

The workshop series included discussions on three main challenges at the product, building and policy scales:

Availability of data and access to low-carbon building products

Participants highlighted challenges to accessing reliable and accurate building product emissions data and EPDs. They noted there are limited accounting tools for estimations or comparison of products' embodied carbon emissions on which to base design or procurement decisions. They also noted the increased costs often associated with alternative low-carbon products remains a significant challenge to mainstreaming them into Canadian building projects.

Integration of whole building emissions assessments and tools into current building information and project delivery processes

Participants noted that the limited availability and accuracy of building product data has also created challenges in use of building-scale LCAs tools since those tools often rely on product-level data. Additionally, although a number of WBLCA tools exist in the market, there is significant variation in their algorithms and databases, and their results and models are not comparable. Lastly, project teams are struggling to integrate building-scale LCA into their design and construction workflows as current LCA tools do not necessarily align with the types of building information, design tools and decisions made at different stages throughout the delivery of a building project.

Challenges and successes of policies and regulations related to low-carbon products and buildings

Workshop participants highlighted that creating embodied carbon policy is complex because reducing embodied carbon emissions is just one aspect of effective low-carbon building design and material manufacturing. Additionally, embodied carbon emissions occur across products supply chains, adding complexity to tracking and reporting. Participants confirmed that Canada lacks an effective embodied carbon ecosystem, which must include product and building-scale LCA disclosure policies, baselines, incentives and guidelines. They also raised their concern about the limited time available to assess these policies effectiveness and the urgent needs to reduce carbon emissions in buildings.

Recommendations

The following section outlines the recommended actions distilled from the workshops into five common themes. These highlighted actions represent potential pathways to address barriers and challenges in implementing embodied carbon policies and aim to mainstream low-embodied carbon products and buildings.

1. Create Effective Embodied Carbon Policy Ecosystem. As Canada's 2030 net-zero GHG emissions goals approach, policymakers across various levels of government and industry leaders must collaborate to develop effective embodied carbon policies for buildings and integrate them into national GHG emissions tracking and reporting. These measures should leverage existing systems and ongoing efforts, including integrating building-scale embodied carbon emissions into GHG emission inventories and existing policies such as carbon taxes, carbon caps, building codes, rezoning requirements, and land use plans. In addition, embodied carbon reduction policies should also be combined with other low-carbon building approaches, such as encouraging retrofits rather than demolition of existing buildings and developing markets for the reuse of building materials.

An effective embodied carbon policy will depend on reliable, consistent and accurate building and product emissions data as well as clear standards and guides to generate this data. This requires regulations and actions that incentivize or mandate manufacturers to generate and regularly update their product emissions data as well as conduct third-party verifications to ensure data accuracy and comparability. With consistent and accurate product data, governments and industry leaders can create more effective local and regional building standards and guidelines for low-carbon procurement decisions and emissions reporting.

Whole building-scale LCA are important to estimate building embodied carbon emissions across the entire life of a building, including the replacements of components and the options for the end of the buildings' life. However, certain key components (e.g., interior finishes, MEP, refrigerants) are often excluded from the assessments due to lack of reliable data and LCA practices are not part of mainstream building delivery processes. Provinces can implement a stepped approach, beginning with voluntary or incentivized LCA reporting, collecting building data and establishing baselines and voluntary targets. As practices progress, these can evolve into prescriptive measures or more stringent performance targets. With support from provincial governments, municipalities can also test pathways for LCA integration in line with the local industry practices and knowledge base, at appropriate levels of design development.

Government and industry can also work together to develop resources that support and streamline the integration of LCA into building development. These resources could include national or localized guidelines, templates and models that government staff can use to inform policy and practitioners can use to comply with reporting requirements. The Canadian Federal Government's Standard on Embodied Carbon in Construction could serve as a model. Federal and provincial governments must also work to integrate embodied carbon into national building code.

2. Increase access to consistent and comparable database and LCA tools. LCA and carbon accounting tool developers must work with both policymakers and industry practitioners to deploy user-friendly tools that are capable of providing accessible and reliable product data for more effective decision-making in reducing embodied carbon emissions in buildings. The tools must provide transparent background databases of materials and product emissions information, and should be updated regularly to address gaps and changes in available low-carbon products or regional factors that influence results. Where possible, databases should also be expanded to include MEP equipment and refrigerants, and strategies should be developed to address reuse of materials and products. Regular audits or third-party verification can be used to help ensure data accuracy and consistency across tools and databases. Additionally, the expansion of BIM in design and construction provides opportunities for greater integration of LCA tools and product data into BIM-based modelling, adapted for different levels of design and decision-making throughout the project.

3. Incentivize low-carbon material and buildings development. Policies and regulations requiring building product emission disclosure and LCA reporting need to be accompanied by incentivization. Offering incentives to manufacturers can encourage the release of their emission data and incentives for project teams can help offset additional costs associated with conducting LCAs. Federal and provincial governments can introduce funding or subsidies for manufacturers, owners, developers, suppliers, and buyers to promote the supply and use of low-carbon products, including those that are recycled and reclaimed.

4. Foster embodied carbon expertise through training and education. Industry bodies, academic institutions and government agencies can collaborate to create and offer training and educational resources targeting both policymakers and practitioners. This could include education and training on policies, regulations, standards, tools and reporting, as well as enhancing professionals' skills to facilitate discussions on the trade-offs of low-carbon buildings with owners. These training programs could be sector specific or actively involve a wide range of industry practitioners, specialized consultants and government staff to promote mutual learning and understanding. Provincial and local governments and professional bodies can also stimulate demand and supply for embodied carbon knowledge and skills through accreditation, continuing education, and though requirements in emissions-related reporting submittals.

5. Test pathways to net-zero embodied carbon in buildings. As embodied carbon policies mature, the effectiveness of different approaches and requirements will need to be tested and validated at both an individual building level and at a policy levels, through the data collected in voluntary and mandatory reporting. The evaluation can be elaborated through practical and real-world examples using demonstration and pilot projects. Governments can continue to utilize government and public funding projects to demonstrate best practices, and support the creation of case studies aimed at identifying prescriptive strategies and pathways, as well as expand the development of innovation policies to explore the effectiveness of different regulatory strategies. This leadership could lay the groundwork for broader market development and industry advancement; however, it will require great coordination and collaboration across multiple levels of government and among local governments within the region.

The Pathways project team will continue engagement with stakeholders, fostering meaningful connections, and identifying collaboration opportunities. The learning from the Challenges-to-Solutions Workshops will be used to inform the development of research and knowledge mobilization activities to understand the challenges associated in embodied carbon policies and practices, and the potential solutions to accelerate progress towards Canada's net-zero goals. The Pathways project team will continue to work closely with workshops' participants and their networks to advance shared goals and initiatives to mainstream low-embodied carbon products and buildings.

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APPENDICES

Appendix I: Attendees Information.

NAME	ROLE/ PROFESSIONAL TITLE	ORGANIZATION
Matthew Schimdt	Research Student - Architect	Royal Roads University
Haibo Feng	Assistant Prof.	UBCV - Faculty
Omar Swei	Assistant Prof.	UBCV - Faculty
Qingshi Tu	Assistant Prof.	UBCV - Faculty
Caroline Butchart	Structural Engineer	CLF BC
Natalie Douglas	Program Manager	CLF/ZEBx
Roberto Pecora	Mechanical Engineer and Director	ZEBx
Jennifer O'conner	Sustainability Consultant	Athena
Elisabeth Baudinaud	Principal - Engineer	Carbon Wise
Anushka Karmalka	Sustainability Consultant	DIALOG
Mona Lemoine	Sustainability Consultant	DIALOG
Stephanie Dalo	LCA Specialist & Program Manager	CLF/ BC
Stephanie Fargas	Architect	DIALOG
Elise Woestyn	Architect	HCMA
Rebecca Holt	Architect	HCMA
Vijitha Mammen	Architect	HCMA
Mehdi Ghobadi	Researcher and Engineer	NRC
Shuang Liang	Policy Analyst	NRCAN
Soldad Reeve	Policy Analyst	NRCAN
Amy Brander	Energy Advisor - Engineer	Perkin&Will
Forest Borch	Energy Advisor - Engineer	Reload Sustainable Design
Helen Goodland	Architect	Scuis Advisory
Juan Luis Rivera Espinosa	Building Researcher	UBC C&CP
Penny Martyn	Policymaker	UBC CCP

NAME	ROLE/ PROFESSIONAL TITLE	ORGANIZATION
Ralph Well	Community Energy Manager	UBC CCP
Iain MacFadyen	LCA Specialist Lead	ZGF
Tim Meyers	Architect	ZGF
Lona Rerick	Architect	ZGF
Robert Cooney	Senior Policy Advisor in Buy Clean	TBS
Ryley Picken	Policymaker	TBS
Cassidy Burke	Policymaker	TBS
Alex Leffelaar	Policymaker - Engineer	City of Nelson
Zahra Teshnizi	Senior Planner	City of Vancouver
Chris Moore	Policymaker - Engineer	City of Victoria
Agustin Falcon	Policymaker	GoBC
Connor McNee	Policymaker	GoBC
David Gill	Policymaker	GoBC
Kika Mueller	Policymaker	GoBC
Mary Halton	Policymaker	GoBC

Appendix II: Backgrounders of the change-to-solution workshop series.

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Pathways to Net Zero Embodied Carbon in Buildings: Barriers and Solutions to Effective Policies and Actions

About the project:

The goal of the project is to identify barriers and challenges to implementing embodied carbon policies and actions, and to explore immediate solutions in collaboration with academic researchers, local and regional policymakers, and building practitioners. The solutions can take a variety of forms but will all aim to advance policy and practical strategies along the pathway to Canada's net-zero carbon emissions targets by 2050.

This project was undertaken with the financial support of the Government of Canada.

Key project objectives:

- Identify barriers and challenges to the implementation of local and regional policies and regulations to reduce embodied carbon emissions from building materials,
- Identify and develop potential solutions to urgent challenges through collaborative and applied research projects, building on the collective expertise and experience of government, industry, and academia,
- Create pathways or models to pilot and test proof-of-concept policy solutions and analyze their effectiveness, as well as related benefits, constraints, and trade-offs,
- Create educational and skills development materials and activities around policies and regulatory barriers and solutions, to increase capacity and inform and motivate change in government and industry.

Key Project Activities:

- Activity 1: Collect information on the current state of embodied carbon emission policies and actions, with a specific focus on British Columbia, and document preliminary understanding of barriers and challenges,
- Activity 2: Conduct a series of facilitated workshops with representatives from government, industry and academia to confirm the barriers and challenges, develop ideas for solutions to these barriers and challenges, and identify a shortlist of immediate challenges and potential solutions to pursue through collaborative projects,
- Activity 3: Develop and support a small number of pilot projects exploring solutions with collaborations between academic researchers and government and/or industry professionals,
- Activity 4: Conduct knowledge mobilization to document learning and develop educational materials to help advance government and industry knowledge and skills.

Key Terminologies:

Embodied Carbon:	Life Cycle Assessment (LCA)	. Whole Building Life Cycle Assessment (WBLCA)
The greenhouse gas emissions associated with materials and construction processes such as resource extraction, manufacturing, installation, use and end-of-life processes of the building's materials.	A set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a building/ product throughout its life cycle.	A type of LCA, that covers all life-cycle stages of a building and measurements impact across multiple major environmental indicators (not just carbon emissions).

Terminologies reference: Driving Action on Embodied Carbon in Buildings, RMI 2023

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Workshop 1: Low Carbon Products

About the workshops:

We have planned three, two-part workshops between November and December 2023, with potential follow up engagement in winter of 2024. Each workshop will focus on one main challenge identified through conversations and literature reviews undertaken in Activity 1.

The expected outcome of the workshops are to (1) refine the broad challenges into more nuance based on the personal experiences of the workshop participants, (2) identify potential and practical solutions again based on participants experiences and knowledge (3) explore the scalability and application of systematic solutions to accelerate embodied carbon policy and practices.

Workshop 1: Low carbon products for Canadian buildings:

The potential challenges linked to low carbon products (data availability and supply chain) include:

- Limitations of low-carbon materials available in the Canadian market,
- Limitations of manufacturers or suppliers producing low-carbon materials,
- Lack of product information on building materials embodied carbon emissions, constructability, and performance,
- Variation in methods to quantify and document carbon emissions from materials and building products,
- Incremental costs associated with design, procurement or maintenance costs for low carbon materials compared to conventional materials,
- Absence of regulations, standards, and requirement for low carbon products.

Questions for Workshop 1 discussion:

- Refinement of Challenge:
  - What are the challenges faced in collecting and using primary emission data for building products? How are you using this data in your primary responsibility?
  - What are the challenges faced in procuring low-carbon building materials?
- Identification of Potential Solutions:
  - What kind of individual solutions or workarounds have you integrated in your current work setting to address these challenges?
  - What are some of the secondary or unintended consequences (both positive and negative) of implementing these solutions?
- Potential Systematic Solutions:
  - What systematic changes/actions would you like to see to address these challenges (e.g. Building Codes, national standards etc.)? Who would need to be involved in developing and implementing these solutions?

To know more about the project or to explore collaboration opportunities, contact us:

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Workshop 2: Data Availability, Assessment Tools, and Workflow

About the workshops:

We have planned three, two-part workshops between November and December 2023, with potential follow up engagement in winter of 2024. Each workshop will focus on one main challenge identified through conversations and literature reviews undertaken in Activity 1. The focus area of the three workshops is:
The expected outcomes of the workshops are to (1) refine the broad challenges into more nuance based on the personal experiences of the workshop participants, (2) identify potential and practical solutions again based on participants experiences and knowledge (3) explore the scalability and application of systematic solutions to accelerate embodied carbon policy and practices.

Workshop 2: Data Availability, Assessment Tools, and Workflow

The potential challenges linked to data availability, assessment tools, and workflow at a whole building scale include:

- Limitation of comprehensive Canadian region-specific LCA databases for the entire life cycle of a building,
- Variations and limitations of different assessment tools for integrating, assessing, comparing data in entire building life cycle,
- Incremental costs for LCA-related data collection, software licences, and consultant expertise specifically in projects with tight budget,
- Challenges incorporating building life cycle emission assessment processes and results into current design, construction, and operation workflows,
- Challenges in using assessment results to inform design decisions or to comply with regulations.

Questions for Workshop 2 discussion:

- Refinement of Challenge:
  - What are the challenges you have faced in accessing and using building information and tools to assess building-scale carbon emissions?
  - What are the challenges you have faced in integrating these tools and results into your design, construction, and operation workflow?

- Identification of Potential Solutions:
  - What kind of individual solutions or workarounds have you integrated in your current work setting to address these challenges?
  - What are some of the secondary or unintended consequences (both positive and negative) of implementing these solutions?

- Potential Systematic Solutions:
  - What systematic changes/actions would you like to see to address these challenges (e.g. Building Codes, national standards etc.)? Who would need to be involved in developing and implementing these solutions?

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Workshop 3: Policy and Regulation

About the workshops:

We have planned three, two-part workshops between November and December 2023, with potential follow up engagement in winter of 2024. Each workshop will focus on one main challenge identified through conversations and literature reviews undertaken in Activity 1. The focus area of the three workshops is:
The expected outcomes of the workshops are to (1) refine the broad challenges into more nuance based on the personal experiences of the workshop participants, (2) identify potential and practical solutions again based on participants experiences and knowledge (3) explore the scalability and application of systematic solutions to accelerate embodied carbon policy and practices.

Workshop 3: Policy and Regulation

The potential challenges linked to policy and regulation impeding low-carbon products and buildings efforts include:

- Embodied carbon reductions are only one aspect creating low-carbon building, others include (but are not limited to) retrofit strategies, green construction, circular economy, low-carbon manufacturing, and green procurement,
- Limited regulations or standardization on data disclosures for building-scale emission assessments, such as EPD information from manufacturers and suppliers,
- Limited standardization or guidance on approaches to emissions assessments during different points in building development, including the distinction between design or procurement decisions and emissions reporting,
- Lack of emissions baselines or carbon reduction targets for new and existing buildings, and issues with variations across building types and regions,
- Limited expertise and capacity within policy jurisdictions to design and enforce embodied carbon regulations, and limited industry-wide expertise to effectively use emission tools to demonstrate compliance,
- Since policies are new/emerging, there has not yet been enough time to assess effectiveness in reducing actual emissions from building materials,
- Building policies and regulations must be accompanied by regulations reducing emissions in manufacturing, production, and shipping of building components.

Questions for Workshop 3 discussion:

- Refinement of Challenge:
  - What are the policy and regulation challenges you think are impeding mainstreaming of low-embodied carbon buildings and products?
  - How do these challenges connect to different policy jurisdiction (e.g. provincial or federal) and/or industry sectors (e.g. design, manufacturing, construction etc.)?
- Identification of Potential Solutions:
  - Can you think of any solutions to the challenges you discussed previously? Are these solutions more short-term oriented or long-term oriented and do these sometimes conflict?
  - Can you think of any existing policies and regulations that are successful and/or could be adapted or expanded to be successful?
  - What do you currently see as the most important enabling feature of a successful embodied carbon policy or regulation? (e.g., more incentives, more integration into our formal GHG reduction targets, more education/awareness, etc.).

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