Research to Develop a Contractor Toolkit to Reduce Embodied Carbon in New Home Construction

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Disclaimer

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This project was conducted under the mentorship of the City of Kamloops staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the City of Kamloops or the University of British Columbia.

Territorial acknowledgement

The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations. The author also acknowledges that the project outcomes are intended to support activities on Tk'emlúps te Secwépemc territory, situated within the unceded ancestral lands of the Secwépemc Nation.

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Contents

List of figures

List of abbreviations

EPD: Environmental product declaration

ECE: Embodied carbon emission

EC_{BL}: Embodied carbon of baseline

EC_{BM}: Embodied carbon benchmark

EC_{L}: Embodied carbon limit

EC_{p}: Embodied carbon of a proposed project

ECI: Embodied carbon intensity

GHG: Greenhouse gas

LCA: Life cycle analysis

OCE: Operational carbon emissions

SCM: Supplemental cementitious material

VBBL: Vancouver Building By-laws

Glossary of terms

Embodied carbon emission (ECE): Carbon emission related to the production, transportation, erection, maintenance, deconstruction/demolition and disposal/recycling of building materials.

Environmental product declaration (EPD): An internationally recognized document that reports third-party validated information about the environmental performance of a product over its lifecycle.

Greenhouse gases (GHG): These are gases in the atmosphere which allow incoming solar radiation but trap the infrared radiation released by the earth's surface.

Operational carbon emission (OCE): Carbon emissions associated with the energy used to operate a building

Object of assessment: Building and building elements considered in an embodied carbon assessment.

Upfront carbon: Embodied carbon emissions spanning material production to building erection.

Executive summary

The growing global impacts of climate change have prompted international commitments towards reducing carbon emissions. This has impacted the building industry and spurred interest in eco-friendly housing. In the province of British Columbia (BC), Canada, operational carbon emission (OCE) reduction guidelines for buildings have been codified. However, binding requirements for embodied carbon emissions (ECE) are yet to be enacted, except in Jurisdictions like Vancouver with Community Charter powers. Against this backdrop, this study investigated workable strategies that can be implemented to reduce ECE in new home construction in the City of Kamloops, BC. Interviews, surveys and local ground-truthing were conducted to examine the ECE literacy level, building material preferences and perceptions of construction stakeholders about ECE reduction practices, policies and programs. The report concludes with proposals for advancing the objective of reducing ECE in new home construction in the city.

Introduction

Background

Carbon emissions from building operations and material production is a major contributor to global emissions, accounting for 37 % of the total in 2022 (see Figure 1), equivalent to nearly 10 gigatons [1]. In Canada, buildings constitute about 14 % of greenhouse gas (GHG) emissions and represent the third-highest source of emissions in the country, only behind the oil and gas and transportation sectors as detailed in Figure 2 [2]. The federal government's response to safeguarding the environment and reducing the effects of climate change is its comital to cutting emissions by 40 % below 2005 levels by 2030 and net-zero emissions by 2050 in line with the Paris Agreement target [3]. In the province of British Columbia, the target is to reduce emissions in buildings and communities by 59-64 % of 2007 levels by 2030 [4].

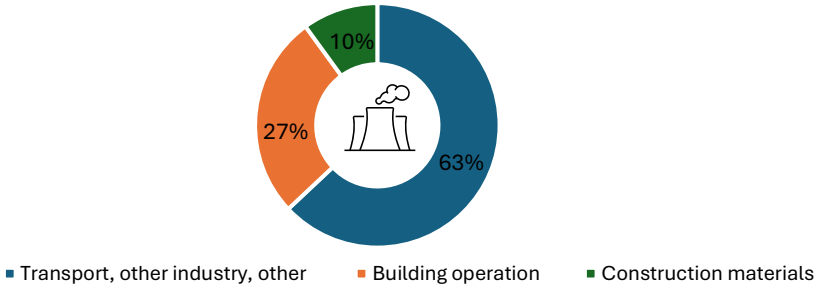

Figure 1: Global carbon emissions by sector [1]

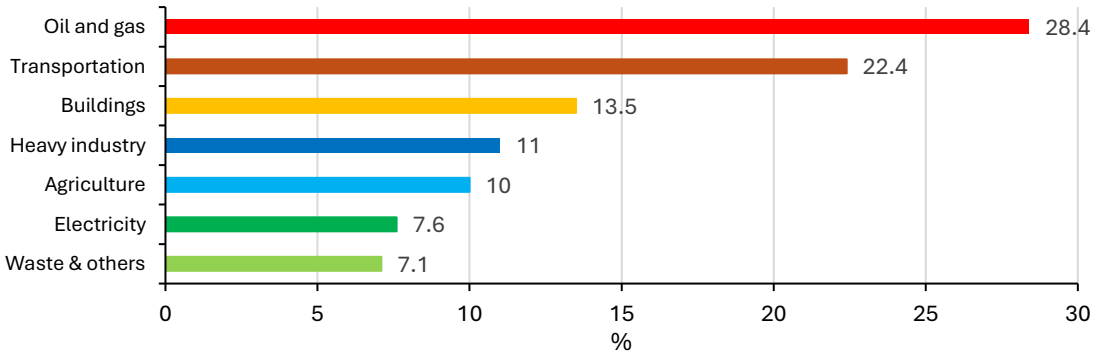

Figure 2: GHG contribution by sectors in Canada [2]

Advances have been made in the improvement of the operational energy efficiency of buildings through the introduction of the Energy Step Code and Zero Carbon Step Code in

British Columbia [5]. The City of Kamloops (the City), through its Community Climate Action Plan, has also set targets to reduce community GHG emissions by at least 30% of 2007 levels by 2030, and 80% of 2007 levels by 2050. The City is also committed to retrofitting 2% of its existing residential units per year to achieve 50% GHG emissions reductions per unit on average.

However, these strategies, like many communities', largely exclude carbon emitted due to the manufacture, transportation, installation, maintenance, deconstruction or demolition, and disposal or recycling of building materials – i.e. embodied carbon emission (ECE), which contributes significantly to carbon emissions from the building industry. Single-family homes in North America are estimated to have 250 kg CO_2e/m^2 of ECE on average[1] [6-8]. The implication of this statistic in the Canadian context is that emissions from building materials for residential buildings may be the equivalent of about 14 million tonnes of emissions per year [9] (for context, the City of Vancouver's community emissions in 2023 were 2.4 million tonnes).

In a more localized metric, the average amount of ECE per house in Nelson, and Castlegar – jurisdictions comparable to Kamloops – is estimated at 28.8 tonnes of CO_2e. In contrast, the average operational carbon emissions (OCE) per house in these jurisdictions is 1.26 tonnes of CO_2e/ year. These data indicate that incremental OCE in these buildings would only equal their upfront ECE after 23 years [10], highlighting the huge significance of ECE.

In British Columbia, the City of Vancouver is setting the pace in embodied carbon reduction. Through its charter powers, the City has incorporated embodied carbon reduction requirements into its building by-law (VBBL) for all new Part 3 buildings per the National Building Code of Canada Designation [11]. The guideline is summarised in Figure 3.

As the City of Kamloops does not have special Community Charter powers like Vancouver, the City plans to utilize creative strategies to reduce embodied emissions in new buildings,

[1] CO_2e is the unit of expression of all green house gas emissions as an equivalent CO_2 emission.

and this study is one of the first steps in identifying such workable strategies in the form of incentives, practices, policies and programs.

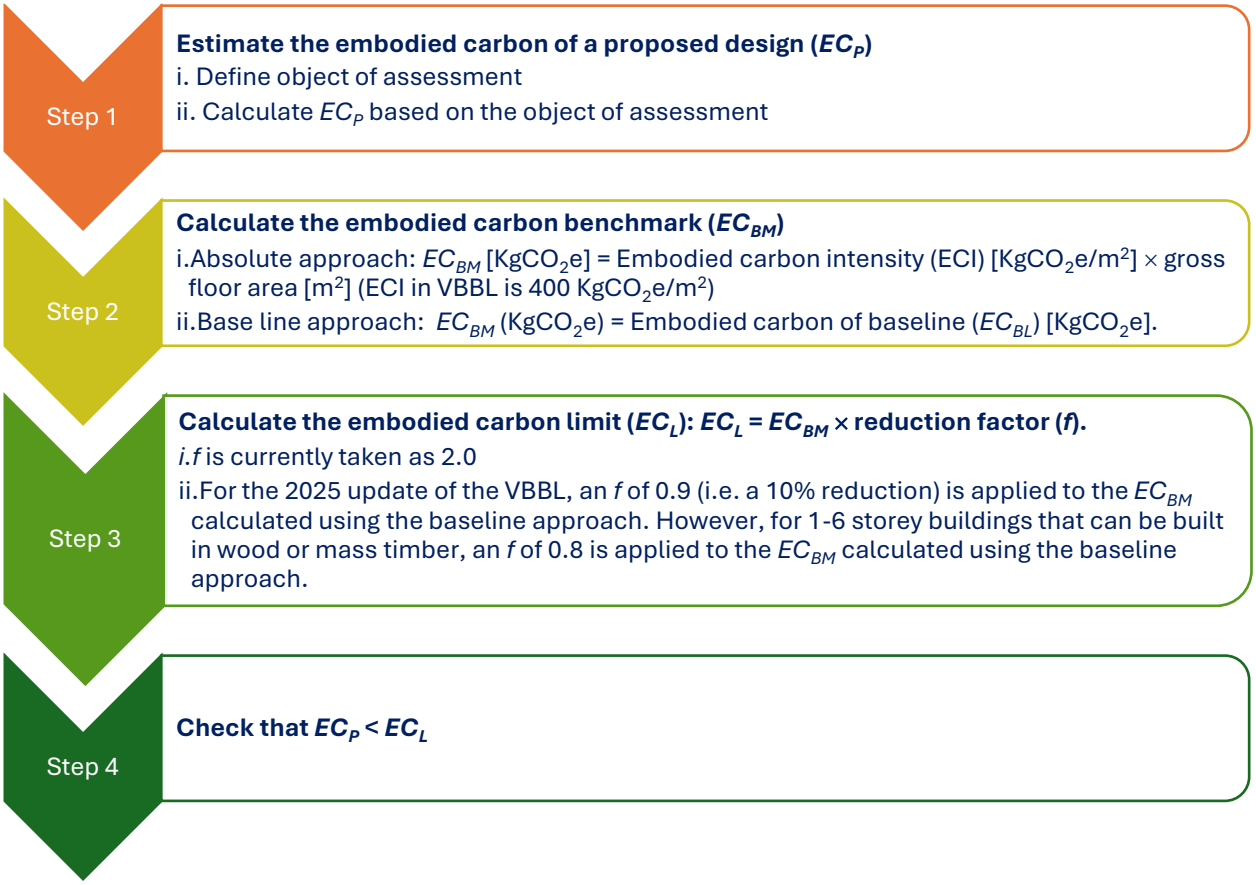

Figure 3: City of Vancouver embodied carbon guidelines [11]

Aim and scope of the study

Shifting the carbon discussion from how we use a building (OCE efficiency) to how the building is made (ECE efficiency), this study is aimed at providing informed recommendations to stakeholders in the building industry in Kamloops about measures of reducing ECE in single-family residential homes, i.e. Part 9 buildings per National Building Code of Canada Designation [12].

As the bulk of embodied emissions (70-90%) occur before the occupation of buildings [13], the scope of ECE considered in this study is from cradle to practical completion (upfront embodied carbon) which includes manufacture, transportation, and installation; but

excludes maintenance, deconstruction, demolition, and disposal considerations as described in Figure 4.

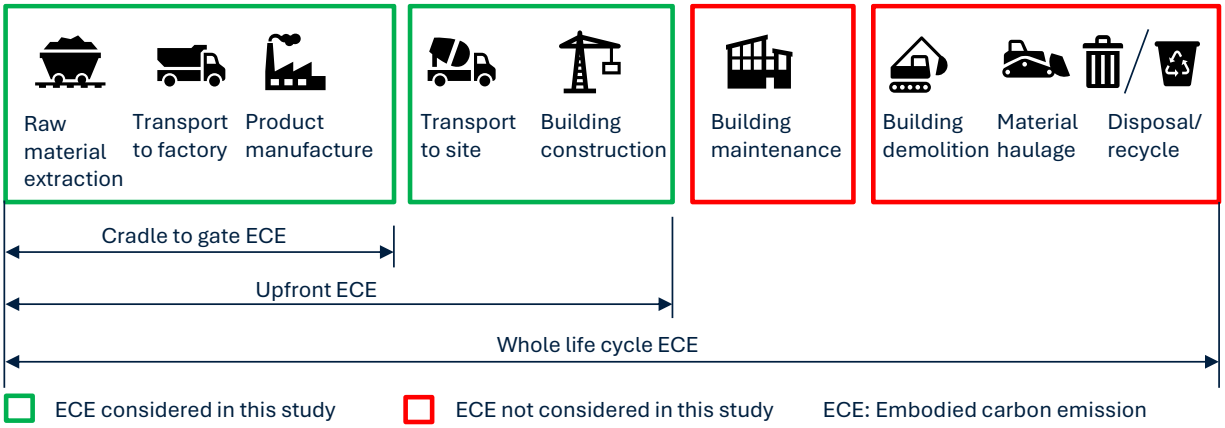

Figure 4: Stages of embodied carbon emission

Methodology

Precursor

Prior studies conducted on ECE in buildings across cities in Canada: Nelson and Castlegar, Greater Toronto Area and City of Vancouver, revealed that low ECE levels were achieved in some instances even when developers did not specifically set out to construct low-carbon houses. By virtue of material choices, unbeknownst to developers, they built low-carbon houses [14] (see Figure 5). The strategy in this study is therefore not to come up with radical ideas for ECE reduction, but to find out strategies executed or proposed in other jurisdictions and recommend those that can be implemented affordably, and practically, in Kamloops.

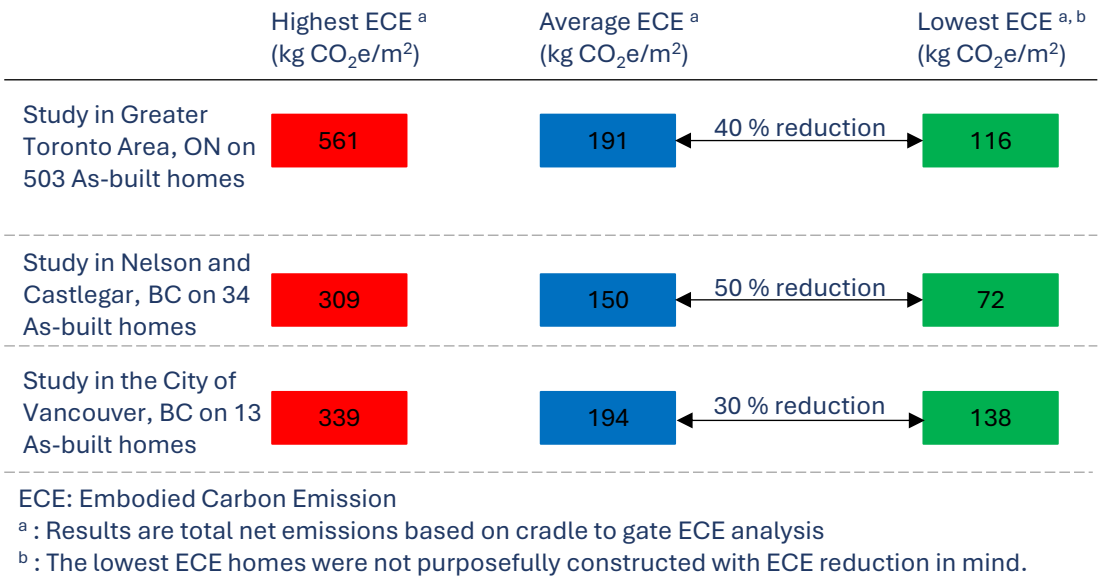

Figure 5: Studies on embodied carbon emissions in homes across Canada [14]

Project work plan

The adopted work plan in this study can be summarised in three main actions:

- Garner recommendations for reducing ECE from the literature, especially those with case studies from comparable jurisdictions to Kamloops, BC, Canada.
- Via interviews, surveys and local ground-truthing, identify the recommendations that can be practically implemented in Kamloops.

- Based on the outcome of interviews, surveys and ground-truthing, proffer Kamloops-specific recommendations for reducing ECE.

Survey and questionnaire overview

The survey and interview questionnaire developed for this study are provided in Appendix A and B respectively. They were primarily developed based on the research and publications on embodied carbon from the cities of Nelson, Castlegar and Squamish [10,13,15]. These cities are comparable to Kamloops in that they are all small cities without jurisdictional authority to lay down building code requirements; however, they differ in population, climate zone and potentially, the market availability of construction material options.

The survey covered the following themes:

- Expertise, experience and ECE literacy level of respondents.
- Concrete, insulation, cladding, and interior surfacing materials specified and utilized by experts in Kamloops.
- Opinions on ECE reduction practices.
- Opinions on ECE reduction policies.
- Recommendations for the uptake of ECE consideration in housing projects in Kamloops

The questionnaire was essentially the survey crafted in an open-ended style question format, suitable for interviews. Four experts with experience in Kamloops, comprising an architect, a tradesman, an energy advisor and a cement supplier, were interviewed. The survey was taken by 13 respondents from Kamloops, equivalent to about a quarter of Kamloops companies registered with the Canadian Home Builders' Association Central Interior in British Columbia.

Feedback from surveys and interviews

Survey participants' information and ECE literacy level

The expertise and experience of respondents to the survey and their level of understanding of the subject of ECE are summarized in Figure 6. The vast majority (85%) of the survey takers were tradesmen, and about three-quarters of the participants had more than ten years of experience. Nevertheless, the ECE literacy level on a scale of 0 to 10 was 5.75 on average, with a high standard deviation of 3.09, signifying a considerable spread in the level of understanding of the subject.

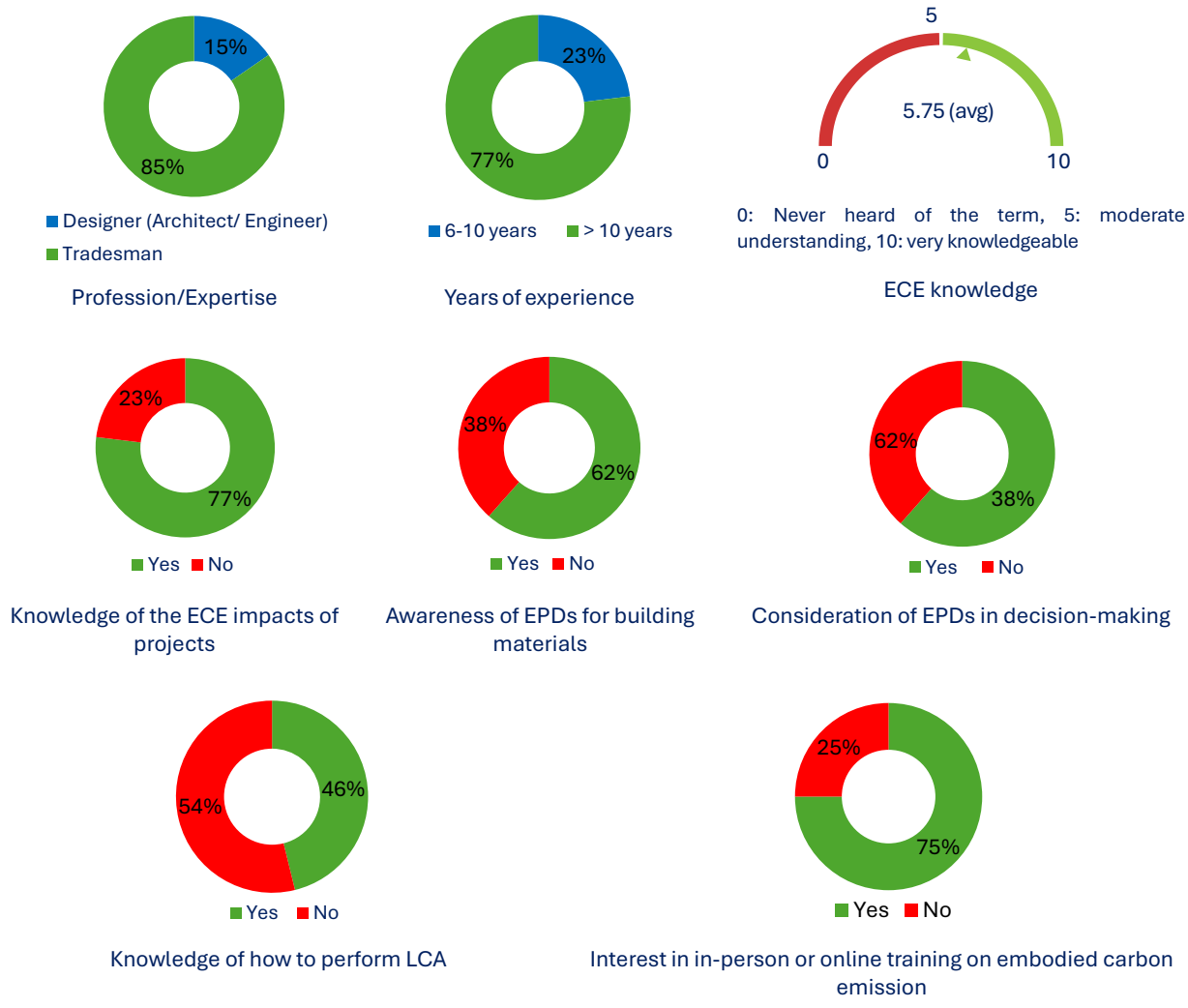

Figure 6: Survey takers' expertise, experience and their ECE literacy level

About three-quarters of the survey takers were aware of the ECE impacts of their undertaken projects, a little less than two-thirds were aware of environmental product declarations (EPDs) for building materials, and about the same proportion did not consider this in making decisions about their projects, while just over half of the respondents know how to perform a building life cycle analysis (LCA). However, most of the participants (75%) were interested in training on ECE.

Frequency of specification/utilization of insulation, cladding, and interior surfacing materials

Figures 7-9 show the leanings of survey takers regarding the specification and utilization of insulation, claddings, and interior surfacing materials. The charts indicate that fibreglass insulation, fibre cement siding, and drywall interior surfacing are the top specified/used materials in Kamloops in their respective categories.

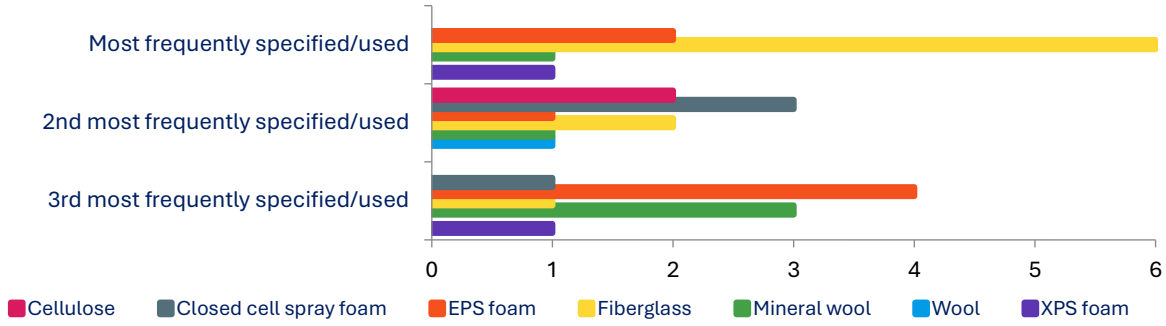

Figure 7: Frequency of specification/ utilization of insulation materials

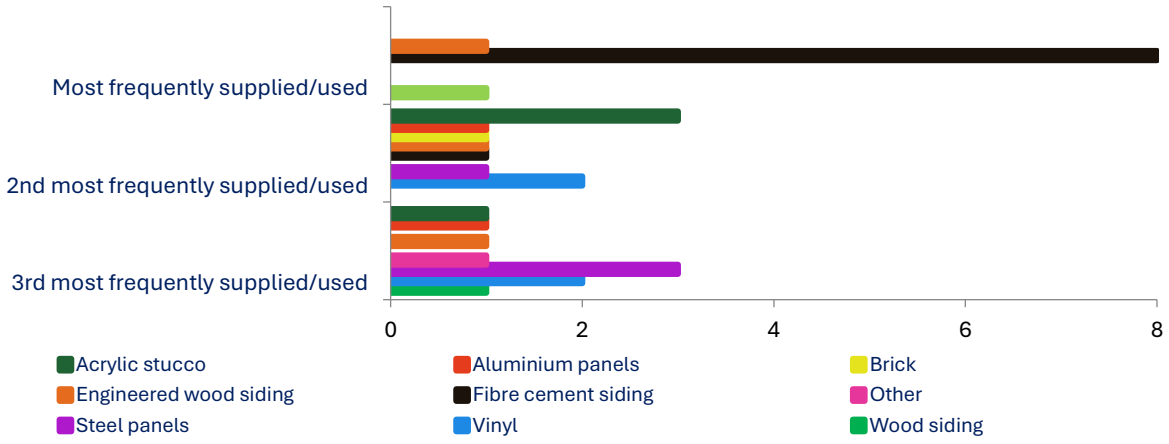

Figure 8: Frequency of specification/ utilization of cladding materials

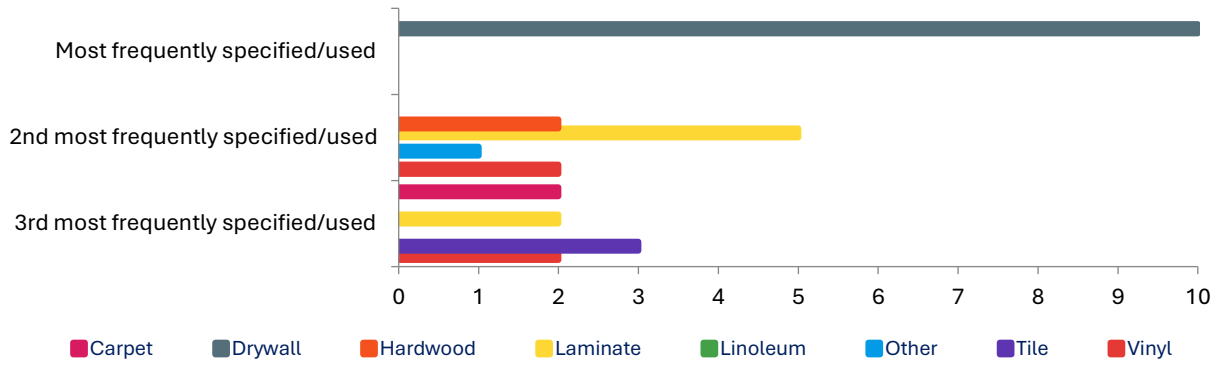

Figure 9: Frequency of specification/utilization of interior surfacing materials

Considering the material carbon emissions guide published by the City of Nelson [15], these statistics indicate a positive trend. Apart from bio-based insulation materials with negative emissions intensity, fibreglass insulation has one of the lowest ECE intensities. Moreover, although fibre cement siding has a relatively high emissions intensity, it is one of the least emitters among cladding materials recommended by FireSmartBC as non-combustible or fire-resistant – an important consideration when integrating climate resilience objectives in home construction. Also, given the wide range of emissions intensity of drywall, mainly due to the synthesizing process of the material, there are opportunities for reducing emissions in this category based on the choice of drywall.

Specification and use of cement/cementitious materials

The survey results on cement specification and utilization in Kamloops, summarized in Figure 10, indicate that ordinary Portland cement features most frequently in concrete mixes, with 83% of respondents indicating that it is regularly used in their concrete mix; followed by Portland limestone cement (17% of participants signified it often features). Limestone calcined clay cement and supplementary cementitious materials only feature occasionally at best, as half and one-third of respondents indicated occasional use of each, respectively. The strong leanings towards the more carbon-intensive, ordinary Portland cement in Kamloops may be partly attributable to the challenges associated with the use of supplementary cementitious materials (SCMs) in the dry climate of Kamloops such as strength gain and concrete finishing.

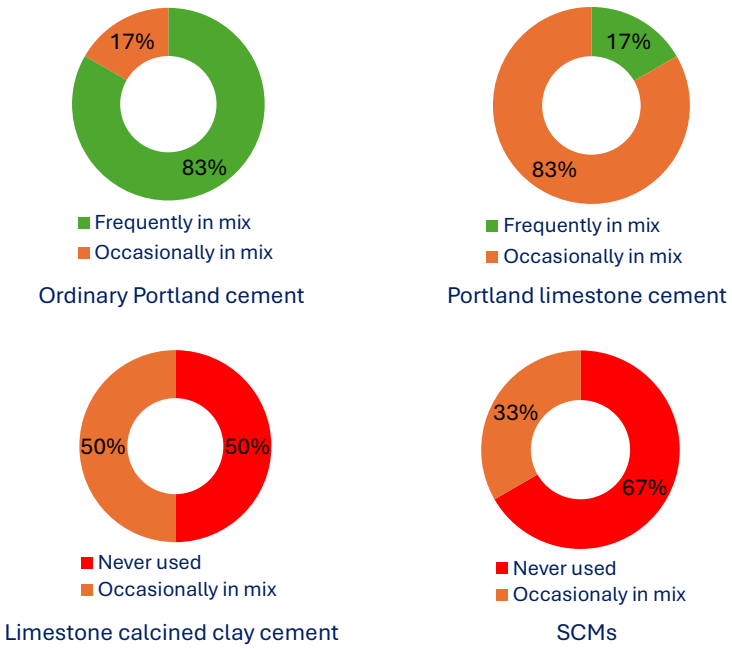

Figure 10: Specification/utilization of cement and cementitious materials

Opinions on embodied carbon reduction practices

The perspectives of survey participants about various embodied carbon reduction practices are summarized in Figure 11. The charts in the black box indicate the most accepted practices, with no registered opposition. Bulk material delivery and modular construction are in this category. The charts in the purple box are practices already being implemented by one-third of respondents but considered difficult to implement by about one-quarter to one-third. These include the use of screw pile foundations and the reduction in building form factor by minimizing inset balconies, recessed entrances, cantilevers etc., which is strongly client-dependent.

Low-carbon concrete options, crack control measures other than rebars in concrete slabs on grade (e.g. use of steel fibres), low-emission construction and transportation equipment, and smaller building grids are already being employed by less than a tenth of respondents, but at least one-third may consider them in future projects. These are grouped in the orange box. The intricacies of finishing steel fibre-reinforced concrete may be a disincentive for its application, while Kamloops' cold winters and mountainous terrain, along with the nascent

state of the medium/heavy-duty electric vehicle market/technology, make low-emission material transportation a difficult proposition at this time.

The pink box contains practices one-quarter or less of survey participants are either already implementing or would consider in the future. Eliminating underground parking and minimizing or avoiding basement footprints are in this category. The low acceptance of these practices may be attributed to the terrain in Kamloops, which is characterized by slopes and undulations, and as a result, often necessitates the construction of basements.

In the gray box are measures either no respondent is currently implementing, or none is interested in considering in the future. These include the use of high-strength, pre-stressed/post-tensioned reinforcement and natural/bio-based cladding and insulation materials. Deeply rooted traditional construction practices and the lack of locally available bio-based building materials make these practices difficult to implement in Kamloops at this time.

In the final category, grouped in the red box, are practices with a high level of pessimism among respondents. Between two-thirds and three-quarters of survey respondents consider them difficult to implement. Concrete-free slabs on grade and salvaged materials are in this group. The latter is often limited to decorative features and not structural applications even though this is permitted in the British Columbia Building Code [16], provided they meet the requirements of the Code for new materials and are suitable for the intended use. Also, while the use of salvaged materials such as recycled aggregates helps in reducing landfill wastes, the direct impact on embodied carbon reduction is not yet clear.

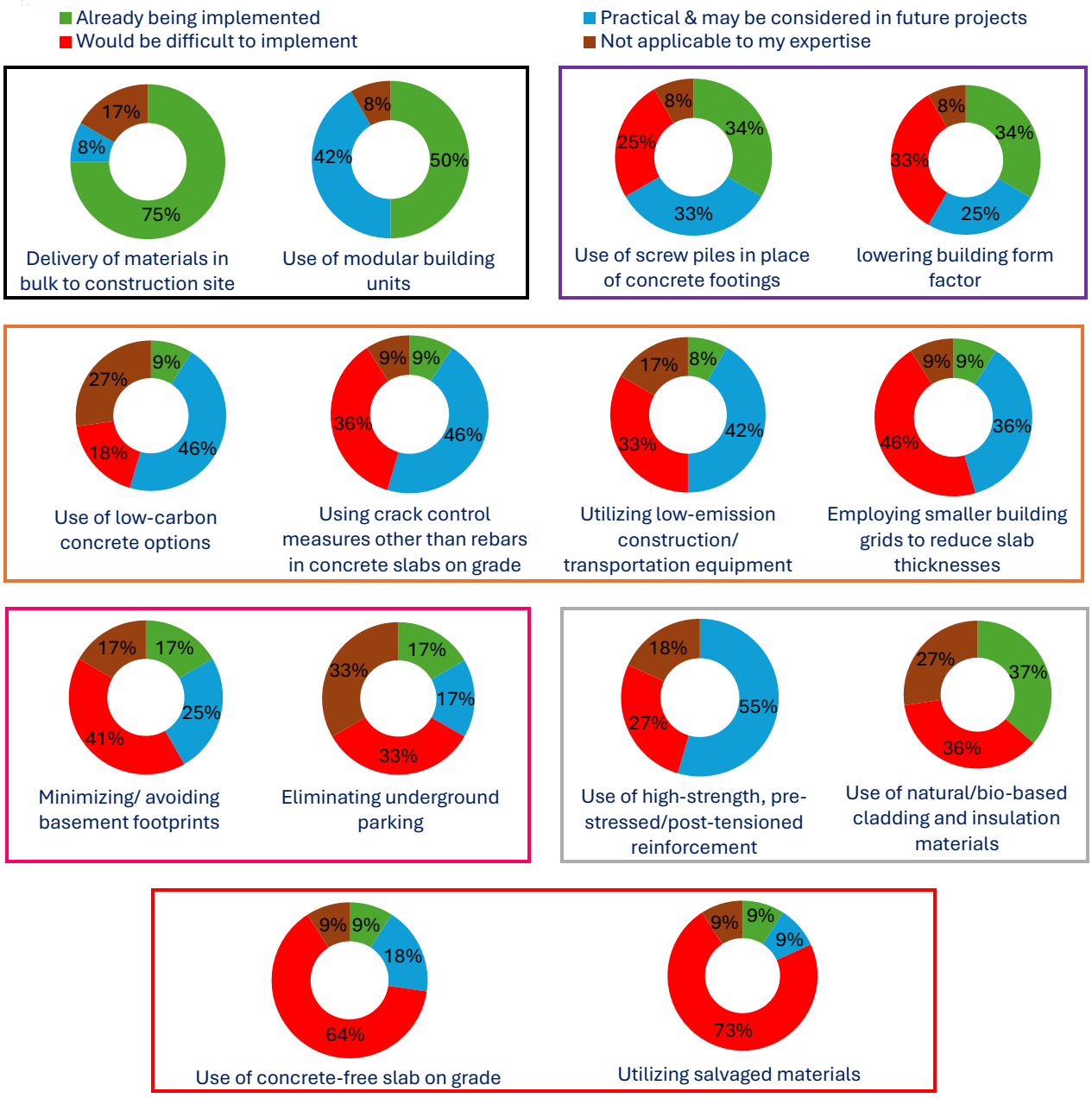

Figure 11: Views on embodied carbon reduction practices

Opinions on embodied carbon reduction policies

Figure 12 shows the opinion of survey respondents on potential embodied carbon reduction policies, arranged from the most accepted to the least. The most popular ones include a phased approach to the introduction of embodied emissions reduction strategies, voluntary embodied emissions reporting through a sustainability checklist, the inclusion of embodied emissions reduction targets as part of the BC Energy Step Code, and permit fee rebates for

meeting certain embodied emissions reduction targets. The worst performing include waste management plan requirements as part of a building permit application, EPD requirements for specified building equipment, appliances, and materials, and banning or limiting the disposal of organic materials.

In addition to the opinion poll, some concerns were also registered about the potential policies. There was the argument that more regulations would increase the cost of housing which would be passed on to the end user. There was also some skepticism about rebates, with the belief that any offset in this regard would lead to an increase in fees elsewhere to maintain government revenue inflow.

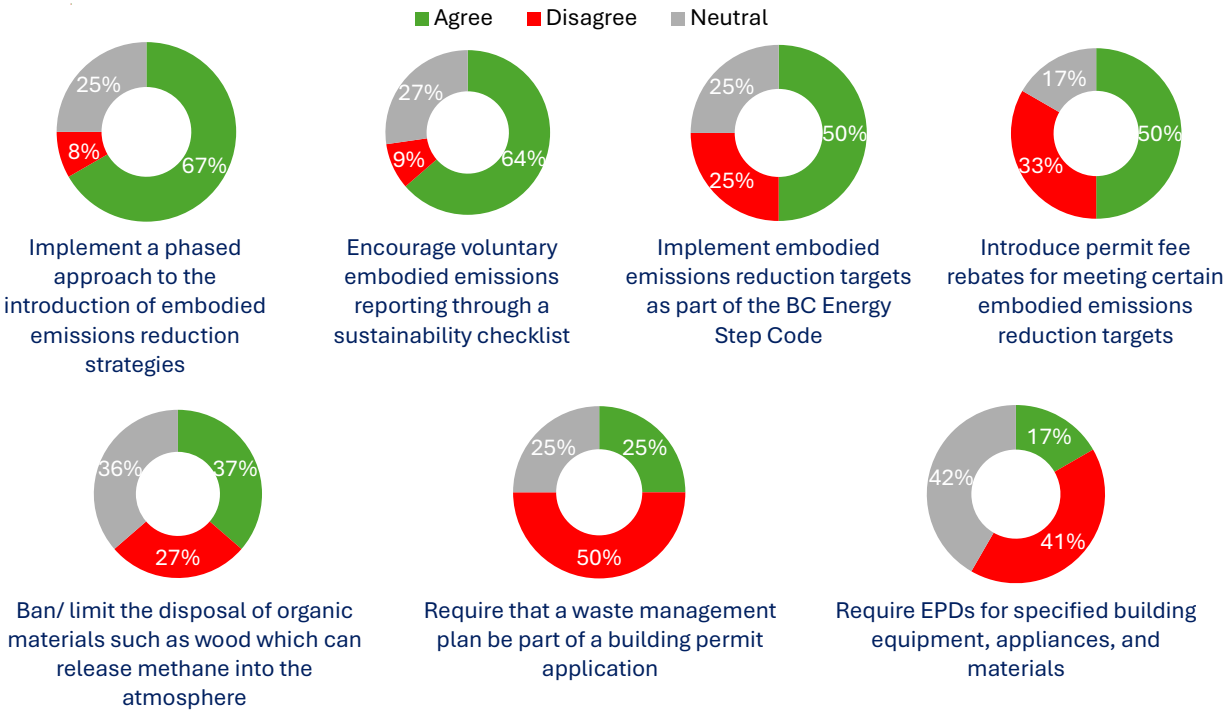

Figure 12: Views on embodied carbon reduction policies

Recommendations for reducing ECE in new home construction in Kamloops

Based on survey results and ideas garnered from interviewing building experts in Kamloops, the following recommendations are proposed to advance the objective of reducing ECE in new home construction in the city.

- Since the carbon emission intensities of building materials vary based on their producers, building professionals and material suppliers in Kamloops should compare EPDs from different manufacturers and make low-carbon choices wherever possible. A useful resource for this is the low-carbon material sourcing guide [17], developed and continually updated by the Climate Leadership Forum, which provides a list of materials that are available within British Columbia together with their carbon intensities and EPDs. It also provides links to the suppliers of these materials.
- Given Kamloops' undulating topography, designers should integrate building designs into the landscape, rather than force in designs. This would help reduce concrete use and carbon emissions during construction.
- Also, since the Kamloops terrain often necessitates the construction of concrete basements which are carbon intensive, rather than utilizing concrete for only structural purposes, considerations should be given to additional applications such as incorporating radiant heating and cooling for maximal utilization.
- Although clients may desire low-carbon housing, cost is often the overarching consideration in building projects. Therefore, outreaches and awareness campaigns should be carried out to allay concerns about the increase in housing costs due to the implementation of ECE reduction practices and policies.
- Traditional construction practices still largely dominate the building industry. Given the average level of ECE literacy among building professionals in Kamloops and the extensive interest in training on this topic, the City should work with its partners (e.g. CHBA-CI, TRU) to consider educational and training initiatives to encourage the uptake of ECE reduction practices, prioritizing the ones that are well-favoured among survey respondents.

- To avoid a sudden disruption of established practices which could put considerable strain on building developers and procurement practices, a phased approach to the implementation of well-accepted policies is recommended.
- Since the sample size covered in this research is limited, a more extensive study should be considered in the future.

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Appendix A: Survey

Part A: Subject expert-specific details

Please select the designation that matches your profession/expertise

- ○ Designer (Architect/ Engineer)
- ○ Material supplier
- ○ Tradesman

Please input the number of years of experience you have

- ○ 1-5 years
- ○ 6-10 years
- ○ > 10 years

Part B: General questions on embodied carbon

On a scale of 1-10, what is your level of understanding of the concept of embodied carbon?

0 1 2 3 4 5 6 7 8 9 10

0: Never heard of the term, 5: moderate understanding, 10: very knowledgeable	

Are you aware of the embodied carbon impacts of the building designs you create or building materials you supply/use?

- ○ Yes
- ○ No

Are you aware of Environmental Product Declarations (EPDs) for building materials?

- ○ Yes
- ○ No

Display This Question:

If Are you aware of Environmental Product Declarations (EPDs) for building materials? = Yes

Do you consider EPDs in making decisions in your projects?

- ○ Yes
- ○ No

Do you know how to perform a life cycle analysis for a building project?

- ○ Yes
- ○ No

Part C: Trends in material specification/ supply/ utilization

Please rank these cladding materials in descending order of frequency of specification/ supply/ use:

	Option
Most frequently specified/ supplied/ used	▼ Fibre cement siding ... Other
2nd most frequently specified/ supplied/ used	▼ Fibre cement siding ... Other
3rd most frequently specified/ supplied/ used	▼ Fibre cement siding ... Other
4th most frequently specified/ supplied/ used	▼ Fibre cement siding ... Other
5th most frequently specified/ supplied/ used	▼ Fibre cement siding ... Other

Please rank these insulation materials in descending order of frequency of specification/ supply/ use and input their sources.

	Option
Most frequently specified/ supplied/ used	▼ EPS foam ... Other
2nd most frequently specified/ supplied/ used	▼ EPS foam ... Other
3rd most frequently specified/ supplied/ used	▼ EPS foam ... Other
4th most frequently specified/ supplied/ used	▼ EPS foam ... Other
5th most frequently specified/ supplied/ used	▼ EPS foam ... Other

Please rank these interior surfaces in descending order of frequency of specification/ supply/ use :

	Option
Most frequently specified/ supplied/ used	▼ Drywall ... Other
2nd most frequently specified/ supplied/ used	▼ Drywall ... Other
3rd most frequently specified/ supplied/ used	▼ Drywall ... Other
4th most frequently specified/ supplied/ used	▼ Drywall ... Other
5th most frequently specified/ supplied/ used	▼ Drywall ... Other

Do you specify/ supply/ use Canadian ready-mixed concrete?

- ○ Yes
- ○ No

Display This Question:

If Do you specify/ supply/ use Canadian ready-mixed concrete? = Yes

Do you know the mix numbers of your specified/ supplied/ utilized concrete as defined by Canadian Ready-Mixed Concrete Association (CRMCA)?

- ○ Yes
- ○ No

Display This Question:

If Do you know the mix numbers of your specified/ supplied/ utilized concrete as defined by Canadian... = Yes

Please rank the concrete mixes that you specify/ supply/ utilize in descending order:

	CRMCA Mix #
	Please only type in numeric value
Most frequently specified/ supplied/ used	
2nd most frequently specified/ supplied/ used	
3rd most frequently specified/ supplied/ used	
4th most frequently specified/ supplied/ used	
5th most frequently specified/ supplied/ used	

Do you know the types of cement/ cementitious materials that are specified/ supplied/ utilized in your projects?

- ○ Yes
- ○ No

Display This Question:

If Do you know the types of cement/ cementitious materials that are specified/ supplied/ utilized in... = Yes

Please select the types of cement/ cementitious materials in your concrete mixes and their frequency of use

	Frequently features in mix	Occasionally features in mix	Never used
Ordinary Portland cement	○	○	○
Portland limestone cement	○	○	○
Limestone calcinate clay cement	○	○	○
Supplementary cementitious materials such as fly ash, ground-granulated blast furnace slag etc	○	○	○
Other (please input below)	○	○	○

Part D: Measures for reducing embodied carbon emissions

Regarding the following embodied emissions reduction strategies, please select the options that apply

	Already being implemented	Practical & may be considered in future projects	Would be difficult to implement	Not applicable to my expertise
Specifying/ supplying/ casting low-carbon concrete options with Portland-limestone cement or limestone calcinate clay cement; or supplementary cementitious materials.	○	○	○	○
Specifying/ supplying/ installing natural/bio-based cladding & insulation materials like wood, bamboo, cork, straw, cellulose, hemp fibre, & wood fibre etc.	○	○	○	○
Specifying/ supplying/ utilizing salvaged materials.	○	○	○	○
Specifying/ casting concrete slabs on grade without rebars, rather, implementing other crack control measures.	○	○	○	○
Specifying/ casting concrete-free slab on grade.	○	○	○	○
Specifying/ supplying/ installing high-strength, pre-stressed/post-tensioned reinforcement.	○	○	○	○
Specifying/ supplying/ installing screw piles in place of concrete footings.	○	○	○	○
Reducing the use of inset balconies, recessed entrances, & cantilevers etc, to lower building form factor.	○	○	○	○

	Already being implemented	Practical & may be considered in future projects	Would be difficult to implement	Not applicable to my expertise
Employing smaller building grids to reduce slab thicknesses.	○	○	○	○
Minimizing basement footprints or avoiding them altogether.	○	○	○	○
Eliminating underground parking.	○	○	○	○
Delivery of materials in bulk to construction site.	○	○	○	○
Utilizing low-emission construction/ transportation equipment.	○	○	○	○
Specifying/ supplying/ installing modular building units.	○	○	○	○

Part E: Policy directions

Please indicate what you feel about these policies in furtherance of embodied carbon reduction

	Choice			Comments
	Agree	Disagree	Neutral	Please feel free to type in your comments
Introduce permit fee rebates for meeting certain embodied emissions reduction targets.	○	○	○	○
Encourage voluntary embodied emissions reporting through a sustainability checklist.	○	○	○	○
Ban/ limit the disposal of organic materials such as wood which can release methane back into the atmosphere.	○	○	○	○
Require that a waste management plan be part of building permit application in order to regulate & minimize the amount of waste sent to landfill by new construction.	○	○	○	○
Require environmental product declarations (EPDs) for specified building equipment, appliances, & materials.	○	○	○	○
Implement embodied emissions reduction targets as part of the BC Energy Step Code.	○	○	○	○
Implement a phased approach to embodied emissions reduction strategies, where changes are incrementally introduced over time, rather than a “cold turkey” cessation of current common practices in the building industry.	○	○	○	○

Part F: Expert feedback

What sort of support do you need to help reduce the embodied emissions associated with your building projects?

_____

_____

_____

Would you be interested in in-person or online training on embodied carbon emission?

- ○ Yes
- ○ No

Display This Question:

If Would you be interested in in-person or online training on embodied carbon emission? = Yes

Please input your email address, if you would love to be contacted about future training opportunities

_____

Appendix B: Questionnaire

Part A: Subject expert-specific details

Company name:
Expertise/profession:
Years of experience/practice:

Part B: General questions on embodied carbon

- Have you heard of the terms 'embodied carbon/embodied emissions'?
- Do you have a clear understanding of these terms?
- Are you aware of the embodied carbon impacts of the building designs you create or building materials you specify/ produce/ use?
- Do you know how to perform a life cycle analysis of your building projects, and the resources available for such purpose?
- Are you aware of environmental product declaration for building materials and is it a consideration in our projects?

Part C: Specific enquiries on embodied carbon

Building design (Building design team – architects, engineers, energy advisors):

- Lower building form factor
    - What strategies do you implement to reduce the building form factor – reducing the use of inset balconies, recessed entrances, and cantilevers?
    - What challenges do you encounter in lowering the form factor of a building?
- Minimizing basements
    - Do you often consider minimizing basement footprints or avoiding them altogether?
    - What are the limitations?
- Reducing the use of concrete
    - How do you try to limit your use of concrete? Do you consider efficient design/alternative design approaches such as not over-specifying concrete thickness or strength, specifying screw piles, concrete-free slab on grade, and no underground parking?
- Optimizing reinforcement
    - Do you consider casting slabs on grade without reinforcement, but rather implementing other crack control measures?
    - Do you utilize high-strength, pre-stressed/post-tensioned reinforcement, which allows less material to be used?
- Specifying natural/bio-based insulation and cladding materials
    - Do you often specify natural/bio-based cladding and insulation materials like wood, bamboo, cork, straw, cellulose, hemp fibre, and wood fibre etc.?
- Employing more efficient building architectural grids

    - Do you often utilize smaller building grids in your designs to reduce slab thicknesses and hence embodied carbon emissions?
    - What are the constraints to employing more efficient building grids?
    - What innovative solutions do you consider in reducing material volume when using large grids? tree columns?

Production (Material suppliers):

- Low-carbon concrete mixes
    - How prevalent is the demand for low-carbon concrete options like Portland-limestone cement and limestone calcinate clay cement; and supplementary cementitious materials such as fly ash, and ground-granulated blast furnace slag in concrete used in Kamloops?
    - What are the limitations to using these in the Kamloops building industry?
- Less carbon-intensive materials/ bio-based building materials
    - What natural cladding and insulation materials are often demanded in building construction?
    - Has the industry in Kamloops embraced natural/ bio-based cladding and insulation materials like wood siding, straw, cellulose, hemp fibre, and wood fibre?
    - Are there drawbacks limiting the use of bio-based insulation/ less carbon-intensive cladding materials?
- Materials with less need for transportation to separate manufacturing plants during production.
    - What modular cladding systems are regularly demanded?
    - Are you aware of the transportation intensity of these materials?
- Use of second-hand/ salvage materials:
    - What salvaged materials are often available in Kamloops and the surrounding area?
    - Where can the salvaged materials be accessed in Kamloops and the surrounding area?
    - What are the challenges to the utilization of salvage materials for construction in Kamloops?
    - Have you been involved in deconstructing and/or salvaging building materials?

Transportation (Material suppliers/Tradespeople):

- Local/proximal sourcing of materials
    - What building materials do you use that are produced/available locally?
- Bulk delivery to the construction site
    - What measures do you take to reduce the number of vehicle trips at various stages of construction?
    - What are the challenges to bulk site delivery in Kamloops?
- Low-emission vehicles

- What transportation methods are often used for site delivery?

Construction/Installation (Trades people):

- Modular construction
  - Are modular buildings often built in Kamloops?
  - What are the limitations to the uptake of this construction technique in Kamloops?
- Site waste reduction
  - What measures do you take to reduce waste on construction sites?
  - What are waste-reduction opportunities not well/yet explored, and what are the limitations to exploring them?
- Low-emission equipment
  - Do you intentionally seek to utilize low-emission equipment in your building projects?
  - Is this equipment easily sourced?
  - What are the challenges to their application?

Part D: Closing question

- What sort of support do you need to help reduce the embodied emissions associated with your building projects?