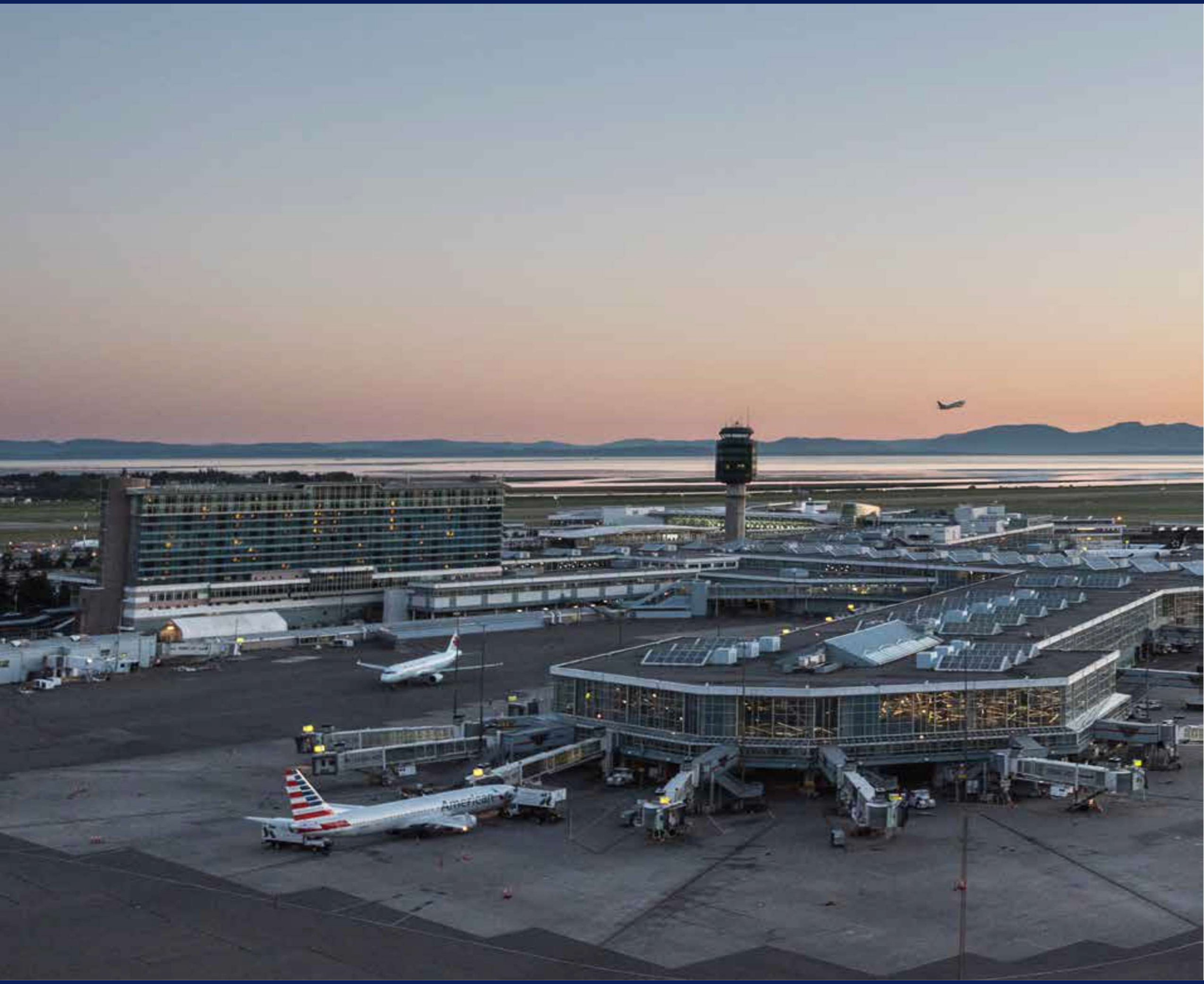
EXECUTIVE SUMMARY



Incorporating Embodied Carbon into Sustainable Decision-Making in Construction

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Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

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Addressing greenhouse gas emissions associated with construction is a key component to fight global climate change. With a target to achieve net-zero operational greenhouse gas emissions by 2050, Vancouver Airport Authority (the "Airport Authority") is considering how to calculate and reduce the life cycle carbon impact of construction activities. This research project included a best practice review and recommendations for the Airport Authority to capture embodied carbon in development projects.

Environment is one of the four pillars of sustainability at the core of all the projects at the Vancouver Airport Authority. The Environmental Management Plan (2020-2024) contains measurable targets in four areas for the Airport Authority, including operational carbon reduction. The CORE Project (sustainable energy system and ground transportation facility) is the first YVR project to incorporate embodied carbon calculations to satisfy requirements of the Envision framework developed by the Institute for Sustainable Infrastructure. Life cycle assessment was performed on the structures in the CORE work package using appropriate tools and databases.

The outcome of this project will help determine how the Airport Authority can address embodied carbon emissions in the development of projects, and how to use this information in making decisions that help the airport achieve its target to reach net-zero greenhouse gas emissions by 2050. Research was categorized into four major segments, including:

1. Explanation of the concept of embodied carbon and life cycle assessment (LCA).
2. Summary of best practice for the technical infrastructure required to address embodied carbon that includes:
   a) Technical tools and databases such as life cycle inventory (LCI) databases, environmental product declarations and life cycle impact assessment (CIA) tools.
   b) Standards and policies including LCA standards, certification programs such as Envision and LEED, and frameworks in place at various organizations.
   c) Embodied carbon reduction through policy, design, and construction strategies.
   d) Case studies where a project has calculated embodied carbon, relevant to airport infrastructure.
3. Review of development projects to determine how carbon is currently accounted for in projects through desktop research and interviews.
4. Documentation of decision-making factors affecting embodied carbon policy and final recommendations to tackle embodied carbon in the coming years.

Embodied carbon refers to the lifetime indirect greenhouse gas (GHG) emissions produced by the construction of any infrastructure. It comprises the GHG emissions from all stages of infrastructure from material extraction, manufacturing of materials, construction activities, maintenance and repair of the structure, demolition, and disposal of the materials at the end of the service life. Under the Greenhouse Gas Protocol, embodied carbon emissions are included as a Scope 3 emissions, which are defined as all the indirect emissions that occur in the value chain of the structure, including both upstream and downstream emissions.

Life cycle assessment is the science behind measuring the infrastructure's potential impact on the environment over its entire life cycle. Life cycle assessment (LCA) is an accepted and widely used methodology to calculate the embodied carbon. The LCA process is a systematic, phased approach and consists of four components: goal definition and scope, inventory analysis, impact assessment and interpretation. Under the impact categories in LCA, embodied carbon is accounted as the global warming potential (GWP), which is the account of potential changes in surface temperature due to the increase in the concentration of the GHGs in the atmosphere.

The technical infrastructure that assists the LCA process is LCI databases, Environmental Product Declarations and LCIA tools. These tools are essential to calculate the global warming potential of assemblies/ structures. It is imperative to develop the technical tools, systems, and resources necessary for the construction industry to ensure program consistency and integrity. The standards guide the process to conduct effective LCA, suggest the reporting mechanism of embodied carbon and incentivize the organization to reduce embodied carbon such as through providing certification. Vancouver Airport Authority can take guidance from the policies adopted by other airports and organizations and build industry associations to facilitate further knowledge sharing. Lastly, the industry best practices on embodied carbon reduction can assist the engineering and planning teams at the Airport Authority to make an informed decision on material selection, design changes, low carbon construction practices and reduction strategies.

There are three factors that should be considered to form policies regarding embodied carbon-technical, policy and financial. Based on the literature review and interviews, the following is a synopsis of the requirements suggested in the report (adapted from Embodied Carbon in Construction Policy Primer for Ontario, Zizzo strategy 2017):

Technical Factors

Technical factors entail the use of LCI databases, EPDs, LCA tools, skilled personal and standardized methods to conduct LCA. The requirements for the technical infrastructure are:

- Repositories of life cycle inventory databases and Environmental Product Declaration to provide standardized and reliable underlying data to conduct embodied carbon calculations.
- Easy to use LCA tools should be made available. The staff should be trained on the software for effective implementation.

- Standardized methods and guidance for LCA calculation and reporting are required to create performance benchmarks and best-practice guidelines.
- LCA specialists could be hired to perform the analysis and provide recommendations. The technical infrastructure and resources require significant investment and time to develop. An alternative approach is to hire professional consultants specifically for the projects that can work directly with the design consultants.

Policy Factors

Policy factors influence the strategies that can be adopted to reduce embodied carbon such as certification programs, carbon caps and decarbonization strategies. The recommendations are:

- Target reporting embodied carbon for each project, with the long-term goal to reduce embodied carbon emissions and offset the remaining emissions.
- Third-party certification programs such as LEED and Envision should be adopted to standardize and incentivize the process.
- Embodied carbon policies can be aligned with the existing policies aimed at reducing GHG emissions in the infrastructure.

Financial Factors

Financial factors highlight the estimated investment required and cost-benefit analysis of including embodied carbon in construction projects in the long run. The recommendations are:

- Evaluate the cost of skilled professional and technical infrastructure required for incorporating embodied carbon in a project.
- Construction costs will also depend on the recommended low carbon design practices, which can be made cost-effective if they are considered in the planning phase of the project. It is then possible to encourage materials awareness and set targets and constraints for the design teams. The overall impact is limited when these opportunities are introduced later, and more significant changes will be less cost-efficient.
- Use Triple Bottom-Line Cost-Benefit Analysis to assist in preparing a business case for embodied carbon reduction strategies. This analysis considers the benefits of these low carbon materials in the three pillars of sustainability – environmental, society and economical for the life cycle of infrastructure.