Building the Future

How smart public infrastructure decisions can cut pollution, save money, and support a clean economy

CLEAN ENERGY CANADA

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We would like to thank the following experts for the insights and advice they contributed to this paper:

Adam Auer, Cement Association of Canada

Celine Bak, Analytica Advisors

Aaron Barter & Emma Lowden, Waterfront Toronto

Martin Canning, Evergreen Canada

Liesbeth Casier, International Institute for Sustainable Development

Ron Dizy, MaRS Discovery District

Aaron Freeman, Pivot Strategic

Robert Larocque, Forest Products Association of Canada

Mark Rowlinson, United Steelworkers of Canada

Mike Wilson, Smart Prosperity

Ryan Zizzo, Zizzo Strategy

Key Terms

PUBLIC INFRASTRUCTURE

Infrastructure refers to the fundamental facilities and systems (e.g., buildings, roads, and power supplies) serving a country, city, or other area, including the services and facilities necessary for its economy to function.

EMBODIED CARBON

Embodied carbon refers to the greenhouse gas emissions created in various phases of a building or piece of infrastructure's full life-cycle (e.g. material extraction, manufacturing, construction, maintenance, and end of life/disposal).

LIFE-CYCLE ASSESSMENT

Life-Cycle Assessment or LCA is a standardized method used to quantify the environmental impacts of buildings. It looks at material extraction, product manufacturing, product use, end of life, and disposal.

LIFE-CYCLE INVENTORY

Life-Cycle Inventory or LCI is the data collection portion of LCA. It consists of detailed accounting of all the flows in and out of the product system, including raw resources or materials, energy by type, water, and emissions to air, water, and land by specific substance. This kind of analysis can be extremely complex and may involve dozens of individual unit processes in a supply chain (i.e. the extraction of raw resources such as rocks and minerals, processing them into a product, transportation, etc.) as well as hundreds of tracked substances.

Introduction

The Government of Canada has made tackling climate change a policy priority, most prominently through its Pan-Canadian Framework on Clean Growth and Climate Change. Under that framework, the federal government—together with provincial and territorial governments—has committed to "invest in infrastructure to build climate resilience… reduce disaster risks and save costs over the long term."[1]

The Government of Canada has prioritized increasing infrastructure investment and cutting pollution across the country. The 2016 federal budget saw the launch of the Investing in Canada Plan, the federal government's long-term infrastructure strategy. This plan marks a historic new investment of $180 billion over the next 12 years in five key priority areas: public transit, green and social infrastructure, trade and transportation, and rural and remote communities.[2]

A cornerstone of the pan-Canadian framework is a national price on pollution, which creates an incentive to cut pollution by putting a price on it. Provinces and territories that haven't designed their own systems are subject to the national system as of 2019. Carbon pricing plays a critical role because it harnesses market forces to the service of climate solutions: as the costs of fossil fuels increase, so too does the demand for zero-carbon technologies to heat our homes, power our businesses, and fuel our trucks and trains. Lower-carbon building materials to erect our skyscrapers, pave our roads, and treat our wastewater will also become more cost-competitive.

But now we need to focus on the next step: bringing the two policy priorities of increasing infrastructure investment and reducing pollution together to transform and improve the way government invests in critical infrastructure. Doing so will create less pollution and waste as infrastructure is constructed, and it will ensure our buildings, roads, and bridges are better able to withstand the negative impacts of climate change—such as extreme temperatures and flooding over the long term.

This policy primer will make the case for why we should look to public infrastructure to build the clean growth economy. It will also provide advice to government on how to do that.

Why Infrastructure?

The experts have weighed in: there is a huge opportunity for Canada in changing the way it looks at infrastructure. A new approach will not only reduce greenhouse gas (GHG) emissions, helping Canada meet its pollution reduction targets, it will also support new infrastructure—roads, bridges, and buildings—that can withstand the impacts of a changing climate. An added bonus? Saving money. Using new approaches to fund infrastructure projects that take GHG emissions into account can help to stretch precious taxpayer dollars. It also supports new market opportunities for lower- and zero-carbon materials, products, and services, which are essential to building a robust economy based on clean growth.

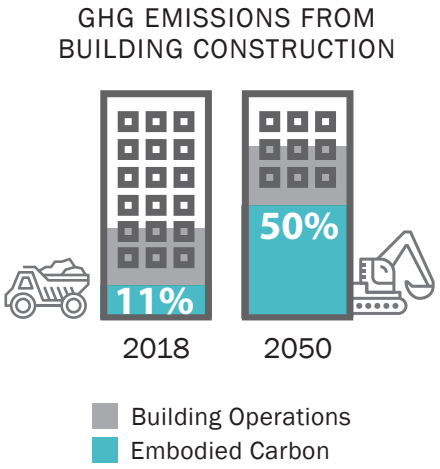
Reducing Emissions

Each time we build infrastructure, whether in the form of a building or a road, we generate GHGs. Generally speaking, the GHGs generated will fall into one of two camps: (1) those that come from the operation of the infrastructure, such as heating a building or running traffic lights and signals on a road; and (2) those that come from the construction of infrastructure, the process used to create the materials used in construction, and how the materials travelled to get to the construction site. Respectively, these are known as operational GHGs and embodied carbon.[3,4]

Overwhelmingly, when we think about infrastructure, we think about buildings. Buildings are our homes, our places of work, and our places of recreation. There is very little we do that does not involve going into a building. Unsurprisingly, this is where the majority of global policy has focused.

According to the latest data from the United Nations Environment Programme, the building sector is the single largest contributor to global warming, with 28% of harmful GHG emissions coming from building operations—e.g. heating, cooling, ventilation, electricity—and 11% coming from the embodied carbon of building materials.[5]

That 11% might sound small compared to the emissions that come from operating buildings, but for new construction, embodied carbon matters just as much. That's because, with an increasingly clean electricity grid and improvements to energy efficiency, embodied carbon will be responsible for almost half of total new construction emissions between now and 2050.[6] The emissions we produce between now and 2050 will determine whether we meet the goals of the 2015 Paris climate accord and prevent the worst effects of climate change.



Source: Green Construction Board, 2014

In Canada, buildings account for nearly one-quarter of our GHG emissions,[7] making them a worthwhile policy area to tackle. But embodied carbon also exists in other types of infrastructure, such as roads and bridges. In the same way a building accumulates embodied carbon through its life-cycle, so does a road. Think for a minute about road maintenance: how often you see construction companies hard at work repaving a major highway? Each time they do, embodied carbon accumulates.

The truth is: tackling embodied GHG emissions in our infrastructure is a win for Canada in both the short- and the long-term. If you build new infrastructure today with materials and construction processes that produce fewer GHGs and are more durable to environmental impacts, you enjoy emissions savings now (i.e. from the initial procurement) and save additional emissions (and costs) in the longer-term via reduced maintenance and repairs.

Photo courtesy of naturallywood.com. Photographer: Brudder

Case Study: Brock Commons Tallwood House

Brock Commons is an innovative tall wood student residence at the University of British Columbia. It is currently one of the tallest mass timber hybrid structures in the world, standing at 18 storeys.[1] Construction of Brock Commons demonstrated that an innovative mass timber-hybrid structural system can cut embodied carbon and is comparable in cost to a traditional concrete building.[2] The building is built with 17-storeys of prefabricated cross-laminated timber floors supported on glue-laminated timber columns and parallel strand lumber columns with steel connections atop a concrete base.[3] Careful design and prefabrication of components offsite allowed for quick installation and assembly, saving further emissions, as well as construction costs.[1] In the end, Brock Commons avoided the production of 679 metric tons of GHGs and sequestered 1,753 metric tonnes more in the building itself.[4] To ensure the building can withstand climate impacts such as fires and earthquakes, Brock Commons was built to fire and seismic safety performance standards exceeding what would be required for a concrete or steel structure of comparable size.[3]

1. The Use of Low Carbon & Renewable Materials in LEED Projects. Case Study: Brock Commons Tallwood House. 2018. As found at: https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/resources/case-studies/lcm-casestudies-bcth.pdf
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3. University of British Columbia's Centre for Interactive Research on Sustainability. Brock Commons Tallwood House Performance Overview. naturally:wood. 2018. As found at: https://www.naturallywood.com/sites/default/files/documents/resources/brock_commons_cs_-_performance_web.pdf
4. "Mainstreaming Mass Wood Construction." Sustainable Architecture and Building Magazine. 2017. As found at: https://sabmagazine.com/mainstreaming-mass-wood-construction/

Cost Savings

Tackling embodied GHG emissions in public infrastructure isn't just about doing what's right for the environment and cutting pollution. It's also about doing what's right for Canada's budget—and your wallet.

Cost savings can be found in the way public infrastructure is designed and by making better use of construction materials and resources. Using fewer materials overall, using materials better suited to the expected life-span of the infrastructure project, and buying materials that are sourced closer to home will reduce material and transportation costs (as well as emissions).[8]

But saving money is also about building infrastructure that can withstand the impacts of a changing climate. Severe weather changes—floods, fires, storms—wreak havoc on our communities and are costing Canadians more and more in insurance claims. The Insurance Bureau of Canada reported that insured damage for 2016—the year of the Fort McMurray wildfires—topped $4.9 billion, smashing the previous annual record of $3.2 billion set in 2013.[9] Canadians are spending more on insurance, and our governments are spending more on disaster relief programs. In the 1970s, disaster relief spending was around $40 million a year, but in the first six years of this decade, federal disaster relief spending rose even more to an average of over $600 million a year.[10]

More recently, a report from the Environmental Commissioner of Ontario highlighted just how much the increased risks from climate-related weather events are costing Canadians: "Intact Financial, one of Canada's largest property insurers, is reported to have raised premiums by as much as 15-20% in response to increasing costs of weather-related property damage. The Insurance Bureau of Canada estimates that up to 10% of Canadian properties may soon be too high risk to be insured by the private sector if no measures are taken to mitigate flood risk by the owner or through public policy."[11]

Supporting Innovation

If Canada wants to reduce embodied carbon emissions in infrastructure and reap the benefits in cost savings that come with it, we need to change how we invest government dollars. Simply put: the only way we are going to do things differently is by buying things differently.[12]

The global market for low-carbon goods and services is worth over $5.8 trillion and is projected to grow 3% per year.[13] Canada's green building industry is worth $23.5 billion in GDP and directly supports an estimated 298,000 jobs.[14] Reducing GHG emissions in our public infrastructure will help accelerate the growing trend of Canadian companies developing advanced green materials and increase their competitive edge and access to both domestic and foreign markets including Europe, Asia, and the United States.[15]

As Canada seeks to reduce embodied carbon in its infrastructure, there are growing opportunities for innovation. New materials, products, and construction processes are emerging that offer a lower-carbon footprint than what might be available today.

Both France and the U.K. have included innovation as components in their respective programs to reduce embodied carbon in their infrastructure.[16]

As Canada looks to build a growing economy with good jobs based on a clean future, encouraging the marketplace to bring innovative solutions forward—such as lower- or zero-carbon building materials and processes—will help to achieve that goal.

Photo: Peter O'Connor

Case Study: M25 Highway Upgrade

In the lead up to the 2012 London Olympics, the U.K. decided to widen one of its busiest thoroughfares, the M25, a 60 km of the highway that loops around Greater London. About 200,000 or so vehicles travel this highway daily. The M25 widening project raised the bar for highway projects in terms of resource efficiency, embodied carbon, and cost savings.[1] The Highways Agency Carbon Calculation tool[2] calculates the project's total carbon footprint and identifies opportunities for carbon savings. The tool showed that 76% of the project's total carbon footprint would result from the embodied carbon and transportation of construction materials. The project team was able to achieve a 27% reduction in embodied carbon through the use of recycled aggregates, the reuse of the existing pavement, and the use of low-carbon recycled steel sheet piles (which were 60% less expensive than virgin materials, also resulting in significant cost savings).[2]

1. SKANSKA. M25 Widening Project, U.K.: Sustainability Case Study 99. 2012.
2. The Carbon Calculation tool considers multiple phases of the project's life-cycle but does not account for the manufacturing of materials or decommissioning. See Highways England Carbon Tool Guidance. 2015. As found at: https://assets.publishing.service.gov.U.K./government/uploads/system/uploads/attachment_data/file/453177/Task_446_Guidance_Document.pdf

What's Happening in Canada?

Like many countries, Canada has brought forward a suite of policies aimed at reducing GHGs in building operations. Canada's electricity-generation mix is already one of the cleanest in the world, with 80% of our electricity coming from renewable or non-emitting sources in 2016—and an aim to be 90% non-emitting by 2030.[17,18] As the country moves towards a complete phase-out of coal-fired power generation by 2030, 16 million tonnes of carbon pollution will be reduced in that year,[19] lowering operational emissions in buildings across the country.

Energy efficiency programs funded by the federal government will also help reduce emissions in building operations, with more than $1 billion from the Low Carbon Economy Leadership Fund over the next five years going to the provinces of British Columbia, Alberta, Ontario, Quebec, New Brunswick, and Nova Scotia.[20]

The Government of Canada has also made a strong commitment to lead by example via its Greening Government Strategy.[21] The strategy commits to reducing carbon pollution from government operations 40% below 2005 levels by 2030 and running government operations on renewable energy by 2025.[22] The strategy contains a number of initiatives aimed at reducing emissions in building operations, including retrofit programs and a net-zero energy building code by 2022.

In terms of policies to reduce emissions from public infrastructure, the path is still fresh. Canada has prioritized public infrastructure spending in green areas such as electric vehicle charging, waste water management, and electricity projects. The government also included green infrastructure in its priorities for the Canada Infrastructure Bank—all steps in the right direction.

The federal government has also introduced a Climate Lens, a requirement that applies to applications to the Investing in Canada Infrastructure Program and other funds such as the Smart Cities Challenge and the Disaster Mitigation and Adaptation Fund. Announced in late spring 2018, the lens contains two components: (1) a GHG mitigation assessment, which measures the anticipated GHG emissions impact of an infrastructure project; and (2) a climate change resilience assessment, which uses a risk management approach[23] to identify and assess climate risks and describe the measures taken to prevent, withstand, and respond to those risks and potential impacts.[24]

Across Canada: reducing GHG emissions using Life-Cycle Assessment

A number of cities and provinces across Canada are using an LCA approach to help reduce emissions in public infrastructure.

The Ontario Ministry of Infrastructure included the integration of LCA into its infrastructure planning, procurement, and business case development as part of its most recent Long-Term Infrastructure Plan—the ministry aims to use LCA in the near future.[1]

The province of Quebec has developed an initiative to increase the use of wood in construction, requiring an LCA-based comparative analysis of life-cycle GHG emissions for structural materials in provincially funded projects.[2]

Both Alberta and Nova Scotia are presently establishing similar Wood Charters as Quebec, which will also require life-cycle emissions data at the funding application stage.

Municipally, Vancouver is taking the lead, introducing a new low-carbon rezoning policy with a compliance path that requires the reporting of embodied emissions using a whole-building LCA perspective.[3]

1. Ontario Ministry of Infrastructure. Building better lives: Ontario's long-term infrastructure plan. 2017. As found at: https://www.ontario.ca/document/building-better-lives-ontarios-long-term-infrastructure-plan-2017/chapter-2-planning-future#section-2
2. Government of Quebec. The Wood Charter. 2017 As found at: https://www.mffp.gouv.qc.ca/publications/forets/entreprises/charte-du-bois-anglais-Web.pdf.
3. City of Vancouver. Green buildings policy for rezoning. 2017. As found at: http://guidelines.vancouver.ca/G015.pdf

According to Infrastructure Canada, the Climate Lens was created to "provide meaningful insight into the climate impacts of individual projects, encourage improved choices by project planners consistent with shared federal, provincial, and territorial objectives articulated in the Pan-Canadian Framework for Clean Growth and Climate Change—including a commitment to reduce Canada's GHG emissions by 30% below 2005 levels by 2030—and provide a substantive eligibility test for projects funded through the Climate Change Mitigation and Adaptation, Resilience and Disaster Mitigation sub-streams of the Investing in Canada Infrastructure Program."[25]

The introduction of the Climate Lens is a step in the right direction, but currently it only applies to a subsector of projects being funded under the Invest in Canada Plan and does not require measurement or reduction of embodied carbon. There is opportunity for Canada to build on this momentum and provide further leadership and support. Working in collaboration with other levels of government, the federal government could expand the Climate Lens and use approaches to measure and reduce embodied carbon, better directing the design, function, and type of public infrastructure we build in Canada.

WHAT'S HAPPENING INTERNATIONALLY ON EMBODIED CARBON[26]

Country	Approach	Tools
The Netherlands	Requirement to conduct whole-building LCA and measure/calculate and report embodied carbon in new residential and office buildings (over 100 m^2) at the building permit application stage	National LCA and EPD database Standard methodology for whole-building LCA Several LCA software tools compatible with methodology
Germany	Requires whole-building LCA for new federal buildings over 2M EURO ($2.8M CDN) as part of a green building rating program. Incentives are offered based on building performance relative to embodied carbon performance benchmarks	Free national LCA and EPD database Free national LCA software tool
Sweden	Requirement to calculate and report embodied carbon in large transportation infrastructure projects (>50M SEK/~$7.5M CDN) during design and construction stages Incentives available for those that achieve further reductions	National LCA database National LCA software tool
France	Voluntary building label pilot program offers incentives for meeting embodied carbon targets for new buildings Plans to make voluntary program mandatory in or around 2020	National LCA and EPD database
Switzerland	City of Zurich requires all new government buildings to be Minergie-Eco standard certified, which requires a whole-building LCA and calculation of embodied carbon.	National LCA database
Belgium	Requirement to register EPDs in a national database whenever making environmental claims for construction products.	National EPD database National calculation methodology in development National software tool in development
U.K.	Voluntary standards BREEAM (buildings), CEEQUAL (infrastructure), and Home Quality Mark (residential) include LCA options but do not require LCA. For instance, BREEAM offers "innovation" points when design teams perform whole-building LCA	National materials LCA database

Looking to the Experts

In October 2018, the National Research Council, in partnership with the Centre for Greening Government, held a consultation in Ottawa on the "development of integrated tools, guidelines and databases to empower Canadians to take carbon-based decision-making actions."[27]

They proposed the development of: (1) a centralized and validated national Life-Cycle Inventory (LCI) database to allow for fair comparison of tendered projects both in terms of life-cycle GHG emissions and the total cost of asset ownership over its lifespan; and (2) infrastructure-specific LCA guidelines and enhanced LCA tools to help provide the step-by-step approach needed to measure, evaluate, and track the full life-cycle of carbon emissions in buildings and other forms of public infrastructure.

We decided to take a deeper dive into these issues with some of the consultation participants and other climate policy experts. We hope the advice provided below is useful as Canada explores how to measure and reduce GHG emissions in its public infrastructure.[28]

Setting the Right Goals

When designing an effective policy, it's essential to set goals. By defining the desired outcomes for your policy and corresponding tenders, the government creates a clear, defined, and transparent set of parameters for the market to respond to.[29] While this paper primarily focuses on reducing embodied carbon in public infrastructure, we asked experts if there were outcomes beyond this that the government should consider in its policy approaches. Four types of outcomes rose to the top.

First, cost savings. Experts recommended focusing on getting the carbon reductions right and reaping the associated benefits in cost savings that come with it. Better designs, processes, and material use can translate into lower costs of construction, operation, and maintenance.

Second, innovation. Reducing embodied carbon in infrastructure and changing government approaches to infrastructure decision-making can foster new green products and services, support innovative Canadian companies, and accelerate clean growth.

Third, increased support for local manufacturing and economic development. Local products don't travel as far from their place of origin to their destination, and being manufactured in a country with a relatively low-emissions electricity grid—and a price on carbon—creates benefits by way of lower-emissions and economic development.[30] One interviewee wisely observed that supporting local jobs and materials can effectively connect the importance of public infrastructure with all Canadians—in a way that just talking about carbon won't.

Fourth, human health, safety, and comfort. While we use roads and bridges, we live, work, and play in buildings. In an effort to find the most GHG reductions, we also have to take into account usability, comfort, and human health and wellness. Consider this: the stairs need to be walkable, the temperature needs to be regulatable, buildings need to be a place people feel comfortable in. Buildings and infrastructure also need to be able to withstand climate impacts such as fires or flooding. Therefore, we need to consider the broader use of the building and how that could be impacted by design or construction.

Building the Right Tools

The key component of the National Research Council's consultation focused on the creation of a centralized and validated national LCI database, a vital tool to inform evidence-based decision-making for public infrastructure. Our experts told us that this is a great start, but that more needed to be done.

First and foremost, the database needs an accompanying tool or system that makes it easy to mine and use the data provided. Creating a complex system of data will be useless unless it is simple and accessible for users. Usability must be a primary focus of government for the database to be successful.

Building the database: design attributes

We asked each of our experts for their top three design features for a national Life-Cycle Inventory database, and here's what we heard:

- Usability, usability, usability! The database must be simple to use, but could consider some enhanced features for LCA experts
- Transparent and accessible
- Based on sound science (and could be subject to third-party review to ensure this)
- The data accurately reflects the regional diversity of the country; some provinces are able to produce materials with a lower GHG footprint than others (i.e. electricity grid)
- Has an internal price on carbon built into it
- Flexible
- Required as part of any government request-for-proposals in building public infrastructure

Second, there needs to be a transparent, accessible methodology on how to calculate and use the data that is based on sound science. This might be different depending on the level of expertise of the end-user. For example, professional practitioners who work in LCA may require, and be more comfortable with, enhanced information; however, the methodology also needs to meet the needs of less experienced users, such as small municipalities looking to assess local projects. The methodology would also seek to ensure that the data collected accurately reflects regional contexts. For instance, the same materials produced in one province may be lower-carbon than another due to differences in electricity mix or other factors.

Third, government also needs to find a way to leverage and benefit from the nimbleness of the marketplace. While it's important that government take a leadership position, that position also needs to be flexible enough to adjust as things evolve, data improves, and new products and building methods are created and deployed.

Finally, and unanimously from all of our experts, the creation of these tools must support a shift in government policy and decision-making. In other words, they need to be made mandatory and applied broadly across all public infrastructure programs. There is little to be gained in GHG reductions, cost-savings, or innovation without taking this vital step.

We recommend government work with other levels of government and stakeholders to set a target for when this new LCI database will be rolled out.

Support for Tools

How we fund the creation of the LCI database and its ongoing upkeep is an important question. While conceivably there could be a model where different institutions pay into it, our experts were unanimous in their advice: this is a tool to support an important policy direction for government (reducing Canada's emissions and building a low-carbon economy), and therefore government should fund the tool as a way of translating its policy values into action.

It could be conceived that once the database and related tools are up and running, some sort of subscription fee could be charged to recover some of the costs associated with continued upkeep and operation of the database—especially because the success of the database relies on maintaining the most up-to-date data. Such an approach would be similar to the approach taken by the Canadian public tendering service, MERX, and the Netherland's DuboCalc system. Government should consider offering different levels of subscription fees based on the type of user; for example, a small municipality may pay a different fee than a large private construction consortium.

Looking Forward

Public infrastructure is powerful. It's where we work, it's where we travel, it's where we play. It is also a huge opportunity for Canada to meet our emissions reductions targets and literally build our future clean economy with good jobs.

The advice contained in this document includes important policy considerations the federal government will need to consider as it develops tools and shapes decision-making around public infrastructure.

There is a need to work in partnership with provinces, territories, and municipalities, as well as industry stakeholders, to change the way public infrastructure projects are determined and funded. The focus should be on solutions that prioritize reducing embodied carbon, saving money, and supporting a growing industry.

We commend the Government of Canada for its work to date, and we look forward to contributing further ideas to the design of specific policies, tools, and programs as they take shape.

Endnotes

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28. Ibid

29. This is what is known in procurement literature as outcomes-based procurement, which was announced in the 2017 federal budget as "solutions-based procurement". Outcomes-based procurement awards contracts based on a proponents'' ability to meet or exceed a defined program result—in effect, the solution to the problem being tackled—in a meaningful and measurable way. For more information, see: The Power of Procurement: Cutting the federal government's carbon emissions

30. For more information on the role of small- and medium- sized enterprises in government purchasing, please see: The Power of Procurement: Cutting the federal government's carbon emissions

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