Buildings For the Climate Crisis - A Halifax Case Study

"The greenest building is...one that is already built[1]" – Carl Elefante, 2007

(Photo: Tim Krochak)

This report was prepared by **Development Options Halifax** with support from **Friends of Halifax Common** and **Mantle Development**.

Development Options Halifax is a volunteer citizens' group working to improve government decision-making by providing better information.

Friends of Halifax Common is a volunteer citizens' group working to protect Canada's oldest and largest Common.

Mantle Developments is a Canadian interdisciplinary climate change strategy consultancy with offices in Toronto and Vancouver.

A very special thank you to the generous members of our community who supported this project.

Image 1: Five-unit Arts and Crafts style Campbell home, 825 Young Avenue, designed by Canada's then foremost architect Edmund Burke 1902, demolished in 2016. (CBC)

"We cannot believe that a situation can be so bad, so desperate that the only solution is to demolish.[2]" — Anne Lacaton and Jean-Philippe Vassal, French architects and 2021 winners of their field's highest honour, the Pritzker Architecture Prize, in part, for never destroying a building to create a new one.

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Executive Summary

Canada's demolition, building and construction sector is adversely affecting our climate crisis and our ability to reduce greenhouse gas (GHG) emissions. The impact includes the release of **embodied carbon**—GHG emissions from construction material manufacturing and processes, transportation and end-of-life disposal/recycling that are mostly released **upfront** (11% of global GHGs); and **operational carbon**—emissions from heating, cooling, and lighting (28% of global GHGs). This total is 39% of global GHGs.

Canada has the worst GHG emissions record of the G7, at least 21% above 1990 levels. By contrast, the US is at 1990 levels, Europe is 25% below and the UK is 42% below 1990. With less than a decade to achieve a 50% reduction in GHG emissions, we must find and implement climate solutions in all sectors.

In the building sector, embodied carbon is largely ignored and unregulated due to a focus on operational carbon, but its reduction must be a part of the solution. As operational energy efficiency is a proxy for carbon, retrofits or new builds don't usually consider embodied carbon in materials used, wasted or land-filled. This omission is preventing us from reaching **net zero carbon.**

A **Halifax based case-study** led by **Mantle Development** finds that two proposed developments for four **high-rise** towers in the Carlton Street block will have a huge and unacknowledged cost to the climate, emitting approximately 31,000 tonnes of embodied carbon in global warming emissions or carbon dioxide (CO_2e) equivalents. This number does not include the estimated 160T from associated demolitions. The majority of these GHG emissions will be released upfront before the buildings are occupied or the doors, elevators, air conditioning, parking garages etc. begin to spew operational and transportation GHGs.

Note that this preliminary GHG emissions estimate is very conservative, since the developers continue to request and receive permission to construct ever taller buildings. Initially proposed for 16- and 30-storeys and 20- and 26- storeys, the preliminary embodied carbon estimate was for new heights of 16- and 30-storeys and ~29 and 30-storeys. 'Now, each of the four towers may be 90 meters or ~30 storeys.'

Buildings at this scale use substantially more carbon-intensive materials—aluminum, cement, glass or steel—than smaller-scale ones. Cement alone is responsible for 8% of global CO_2 emissions; if it were a country this amount of cement would make it the third largest emitter after China (27%) and the US (11%). But there is no room left in a GHG emissions reduction plan to add any new GHGs as we are already failing to meet targets.

And there are additional social costs. The projects will trigger the **demolition** of 12-14 mixed-use, small-scale historic buildings in a central Halifax neighbourhood. These beautiful, character buildings contain approximately 110 affordable residential and commercial units. Their destruction will compromise a total area that is the same as that of three four-storey buildings or a single 12-storey building. The embodied carbon cost to replace this area with a new building is 2,214 tonnes CO2e. This is an irretrievable, unnecessary penalty to the climate and threat to society.

A citizens' group, **Development Options Halifax** (DOH), has examined the space already available on the site to help understand alternatives. It proposes a hypothetical nine-storey **in-fill option** retaining all but one of the existing buildings.This design follows the principle of distributed density; small-scale buildings that fit into empty areas in a city, keeping the existing structural resources and adding to the built environment's diversity. This **mid-rise building option**, along with a renovation of the existing historic buildings, will result in approximately 18,000 tonnes of CO2e, which is 40% less embodied carbon emissions/m2 than the proposed new highrises.

Activity	Invisible Embodied Carbon GHG Emissions (t CO2e)	Embodied Carbon Intensity (kg CO2e/m2)
Developers' towers—construction, demolition, relocation.	~31,000	~360 - 490
Citizens' in-fill option + retained with renovation.	~18,000	~270 – 380 (or with careful planning zero)
GHGs to replace demolished area (~12-storey climate penalty)	~2,214	~360-490

Table 1: Summary of preliminary embodied carbon emissions of proposed Carlton block developments, citizens' in-fill alternative, demolitions climate/social cost.toreys, the DOH proposal'. Note the 31,000T does not include ~160T associated with the demolition of 12-14 buildings.

And here's more good news. At 9-storeys, the DOH proposal's scale offers unique carbon advantages:

- **Low-rise** and mid-rise buildings can more easily use less **carbon intensive** building materials or ones that capture and store CO2 **(carbon negative)**, and can be designed to produce surplus operational energy, via solar panels etc. **(carbon positive)**.
- Buildings at this scale can be built more quickly and at less cost so developers can earn back more on their investment faster and citizens can have more housing options sooner.
- Adding to a city's ecosystem has measurable social, cultural, equity, economic and environmental advantages when compared to city blocks with newer, larger buildings.
- With few exceptions, renovation or repurposing buildings is the best environmental choice creating many more jobs, using fewer materials and releasing fewer GHG emissions.
- Carefully planned retrofits and smaller-scale in-fill designs reduce both climate and societal disruption and harm.

Halifax has a habit of demolitions. From 2003 - 2020 the city issued 2,535 demolition permits[3], estimated to be equal to the area of 17 city blocks. Of these, approximately 50 buildings that were to receive heritage designation under the HRM by Design Plan were demolished. And while the demolition average for Halifax during this period was 140 buildings each year, the annual number of squandered buildings and materials has been steadily increasing, with 101 permits granted in 2003 compared to 188 in 2020.

A building's demolition may seem inconsequential but it is scalable. Worldwide, improving existing building use could potentially cut GHGs by 11% between 2017 and 2050[4]. It is time to avoid, reduce, reuse, recycle, repurpose, add-on and in-fill.

Policy Recommendation 1: Recognizing the carbon cost of demolitions, the material waste and the unnecessary penalty to the climate, society and the economy Halifax, along with all levels of government—municipal, provincial and federal—must immediately prioritize conserving, adapting, and adding on to buildings or in-fill as a first course of action, and if demolition is an appropriate last resort, dismantling and reusing materials more effectively

Over the past decade, the approved height of new buildings in Halifax has increased from an average of 10-storeys to 20-storeys. The city's Centre Plan has recently changed zoning regulations to permit even taller building heights of between 20- and 30-storeys. Other than the city of Vancouver, which is a recognised world leader in establishing targets and timelines for carbon reduction in the building sector by requiring a **carbon budgets**, Canada's local, provincial and federal governments are mostly ignoring the impact of building scale on GHG emissions. That includes Canada's National building codes.

While the high-rise is touted for increased density and affordability, it is not as efficient in land use as is widely assumed. DOH's in-fill option is just one of many possibilities for quickly accommodating housing needs. For example, a single Halifax west-end block can increase its population by as much as 44% using in-fill and third-storey additions with modest 1- 2- and 3-bedroom residential units, while at the same time maintaining 40% greenspace. This adaptive approach can create homes for 66 new households without altering the look and feel of the neighbourhood. By avoiding demolition and carefully choosing materials, this option can also be carbon neutral.[5]

We do not have the luxury of time to reduce emissions by 50% by 2030. In the context of the climate crisis, permitting high-rise buildings at a scale where the materials are known to have an unnecessarily high carbon intensity is a climate crime.

Policy Recommendation 2: Recognizing the carbon cost of large-scale buildings, Halifax and all levels of government must change the rules of development to reduce the impact of the industry by requiring a carbon budget for each new development, and by not approving buildings beyond a scale that can be made carbon neutral. This must include benchmarks for what is permissible now, with targets and timelines for what will be permitted in subsequent years, to enable at least a 50% reduction in embodied carbon emissions by 2030.

Nova Scotia’s Sustainable Development Goals Act advocates the creation of a circular, economy…

> “an economy in which resources and products are kept in use for as long as possible, with the maximum value being extracted while they are in use and from which, at the end of their service life, other materials and products of value are recovered or regenerated.[6]”

Tearing down existing buildings to make way for tall structures, rather than creatively adapting and adding to what already exists, works against this mandate. We’ve used a real Halifax-based example to show the problem and offer possibilities, but all citizens have a role in addressing the climate crisis and pushing for solutions now. Regulation of embodied carbon is an important start.

Planning for a ***circular economy*** with **environmental full-cost accounting**, such as **Genuine Progress Index Atlantic**, needs to include measures for social and environmental well-being to better inform and guide choices. Earth’s resources are finite.

Policy Recommendation 3: Recognizing the limits of growth and the impact of climate change, waste and over-consumption on Earth along with its incumbent inequity all levels of government must change the policies and practices that perpetuate growth in material consumption and production to balance social, environmental and economic measures and create a more equitable human existence. In Nova Scotia this is a focus area of the goals and initiatives established under the Sustainable Development Goals Act that must no longer be ignored.

Transitioning to low-carbon construction requires changes at many levels. Be it carbon negative, carbon positive or real net-zero carbon that includes embodied carbon and eliminates demolition, change must be implemented now. Success stories abound. Inform yourself, tell others and get started. Let the creativity and metamorphosis begin.

Best wishes with your work ahead,
Peggy Cameron, October 2021

Image 2: This block of Carlton Street is the last remaining historic neighbourhood on the Halifax Common. It has Heritage Designation (Municipal, Provincial, Federal) as 'a rare early Victorian streetscape’. Developers plan to demolish 12-14 historic buildings on the three streets adjoining Carlton Street to construct four ~30-storey towers. (Photo: Alvin Comiter)

Introduction

We're in a climate crisis. United Nations Secretary General Antonio Guterres describes the August 2021 UN Intergovernmental Panel on Climate Change (IPCC) report as 'Code Red for Humanity'. An earlier October 2018 IPCC report concludes that we must cut our carbon emissions in half by 2030 to slow global heating to below 1.5°C, and we must get to net-zero carbon dioxide emissions by 2050 to return to a carbon concentration in the atmosphere no higher than 350 parts per million of CO2. As we've already passed safe the levels of warming emissions in the atmosphere, we must not just reduce emissions entering the atmosphere but draw down or remove them.

Immediate action is critical. The longer we delay reducing carbon emissions and atmospheric carbon concentrations the more difficult the task, the greater the social, economic and environmental costs and the less certain the outcome. Canada is one of the most flagrant climate offenders of this century. We may think we're doing ok but we're the only G7 country still emitting GHG emissions way above 1990 levels—21% more. Compare that to the US which is on par with its 1990 levels, the 27 EU countries that are 25% below 1990 levels or the UK at 42% below 1990 levels and it's evident that Canada's contradictory climate policy isn't working. But these other countries' achievements prove that there are indeed solutions![7]

In Nova Scotia all key policy decisions need to align with our 2030 target of 11.5 megatonnes, or approximately 53% below 2005 levels, as outlined in the province' Sustainable Development Goals Act[9]. This reduction is in the order of 6.5 to 8.5 megatonnes. But is the present demolition and building development permit and approval process working to meet this outcome?

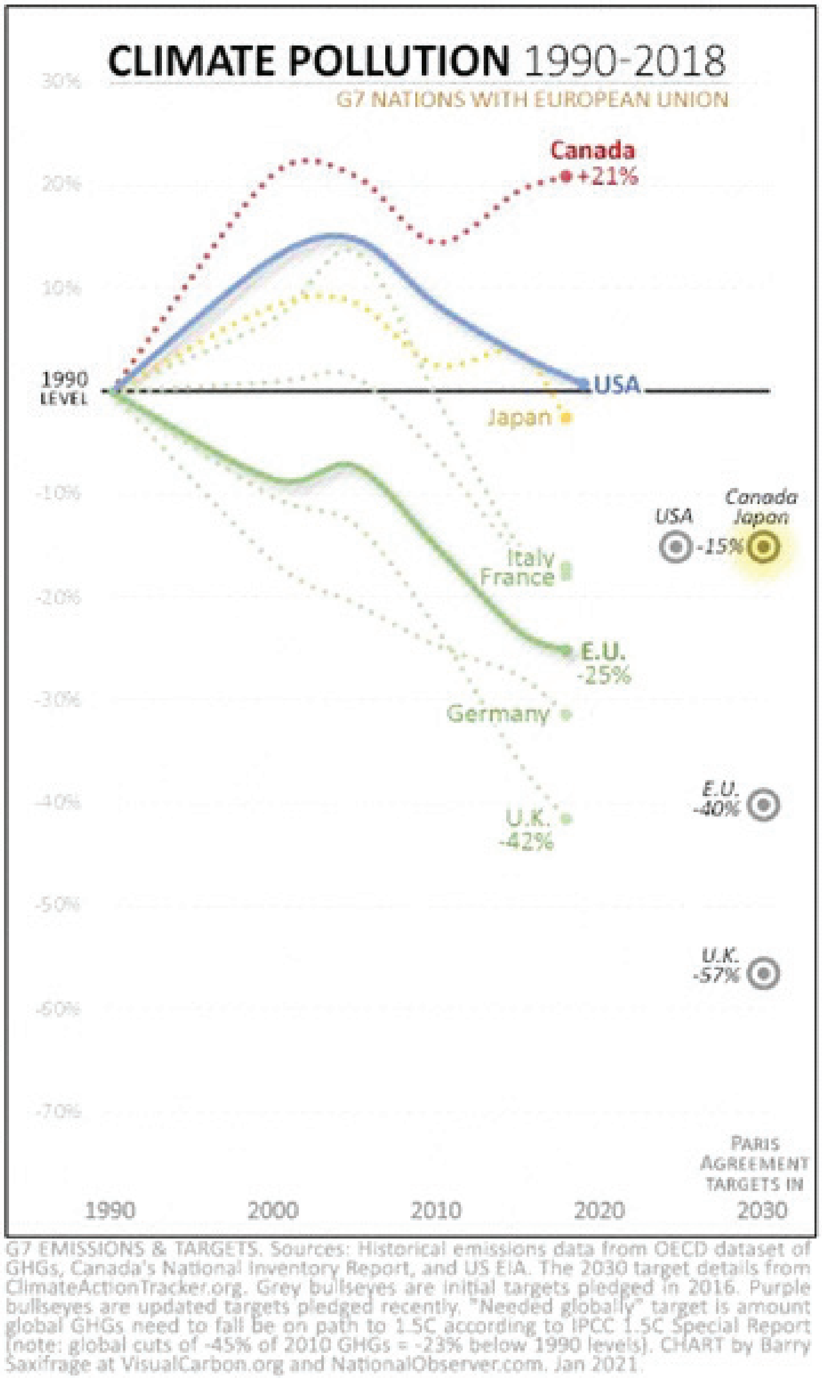

Figure 1: Climate Pollution 1998-2018, G7 Nations and European Union (Saxifrage)[8]

This report looks at the role of the demolition of existing buildings and new construction in the climate crisis and how governments can reduce energy consumption and GHG emissions in this sector. A preliminary analysis of GHG emissions from two Halifax-based proposals and demolitions are compared to an in-fill option, and used as a case study to show how the local decision making in the context of the climate crisis can increase harm or reduce harm.

Solutions abound. These are no longer just opportunities but necessities.
Some individual choices such as switching to a plant-rich diet and reducing both meat consumption and food waste, or reducing reliance on individual vehicle use in favour of public transportation seem small, but have a proven large potential for human and climate health[10]. Other solutions must reduce risk by avoiding what intuitively and measurably seem unsustainable through government leadership, policy and regulation. Between 1995 and 2015 GHG emissions from the extraction and production of materials such as metals, minerals, woods and plastics more than doubled, accounting for a quarter of global emissions[11]. Apart from the climate impact, does it seem even conceivable that this can continue? Simply put, overuse of our biosphere necessitates limits on present-day resource consumption. Remember avoid, reduce, reuse, recycle?

Daily government decisions are driving the climate crisis by not examining these through a climate-crisis lens. Globally, 70% of GHG emissions come from cities, primarily in two sectors; transportation and building and construction. Unless a government is using a set of key indicators to reduce and draw down greenhouse gas emissions as a decision-making tool, they are worsening the crisis. Accurate accounting of GHG emissions to create these indicators is essential. So, the conundrum is, we can't address a problem we haven't acknowledged exists.

Climate Change and the Demolition, Construction and Building Sector

The lifecycle of buildings, that is their demolition, disposal and construction, has a major role in the climate crisis. Together, building materials and construction, along with building operations, cause approximately 40% of global carbon or other GHGs per year[12] (8% from cement alone). Construction is the single largest source of material usage on the planet, equal to 28.7 billion tonnes of material (2019).[13]

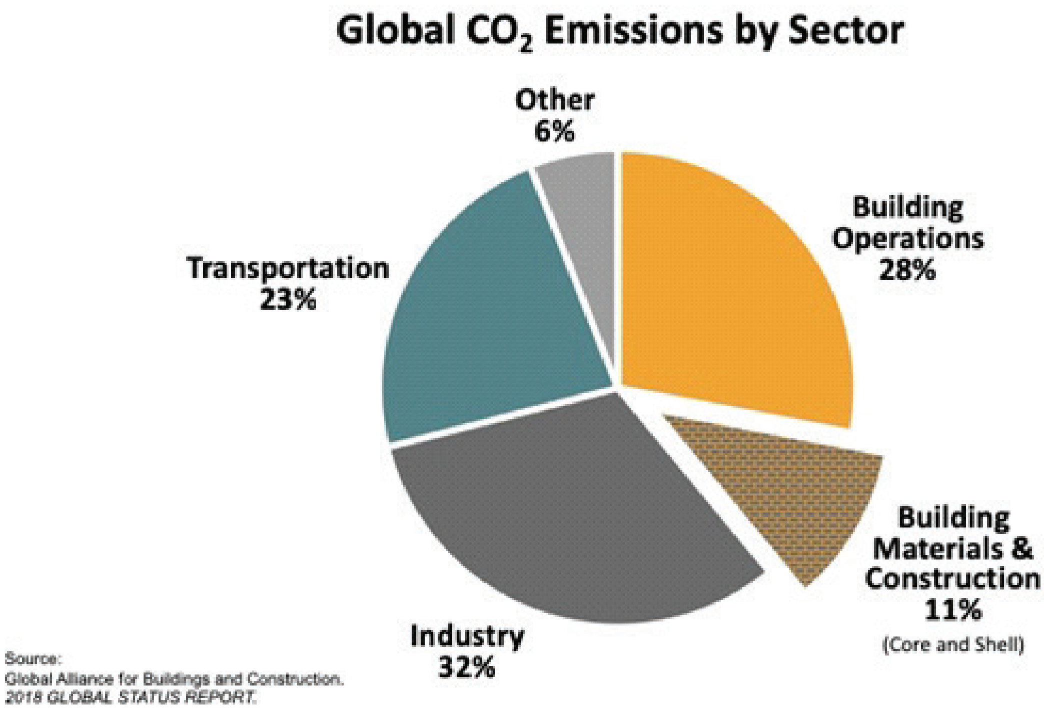

Figure 2: Global CO2 Emissions by Sector (https://architecture2030.org/buildings_problem_why/)

In Canada the building sector is the third largest GHG emitter, and it's growing. Requiring limits for GHGs from this sector and greater materials efficiency and sustainability is urgent and doable.

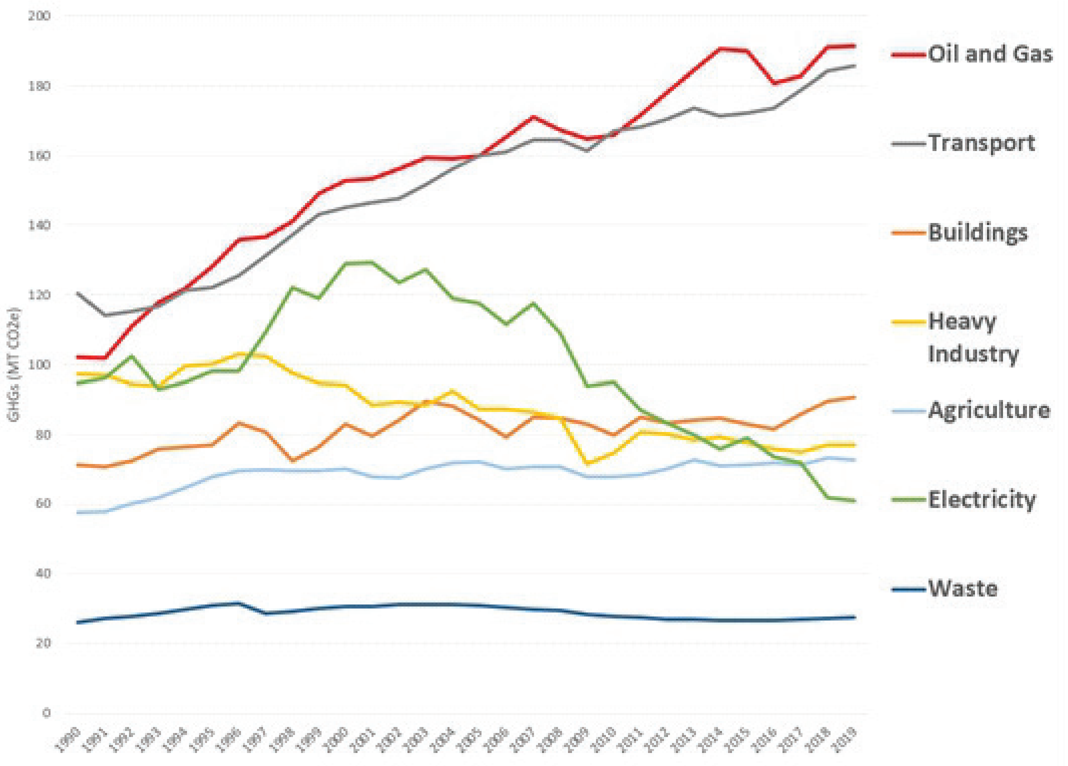

Figure 3: Canada's GHGs by Economic Sector 1990-2019 (Keith Stewart, Greenpeace)

Embodied carbon[14] in the building sector accounts for 11% of global greenhouse gas emissions. It includes all atmospheric warming gases or GHG emissions in CO2 equivalents generated by materials and construction processes throughout the whole life cycle of an asset, from beginning to end. Cradle to grave emissions include: resource extraction, transportation, refining and manufacturing before delivery (cradle to gate); shipping/delivery to customer (cradle to site); construction, installation and construction waste (cradle through construction); and maintenance, renovation, deconstruction and disposal.

Upfront carbon emissions[15] are the portion of GHGs resulting from materials and construction processes up to completion of an asset. While the term "embodied" encompasses all of the GHGs associated with the lifecycle of an asset, it is a confusing descriptor as it implies the carbon is captured or incorporated into the materials, products or building itself. In fact, the majority of GHG emissions for building and construction are upfront in that they are already "spent"—they're the upfront carbon cost of the construction and already released, not to be recaptured.

Most jurisdictions ignore embodied or upfront carbon emissions in virtually all analysis of climate impacts and associated adverse environmental effects. For example, in Figure 3 (above) data for the building sector does not include embodied energy, only operational. As such it remains unregulated, but there's no getting to global net-zero without big changes in this sector. Like every aspect of climate change, there is an opportunity to change how we do business, and it isn't going to happen voluntarily.

Operational carbon emissions in the building sector are responsible for 28% of global GHG emissions associated with heating, cooling, and lighting[16]. In terms of Earth's carbon budget[17] —the cumulative amount of carbon dioxide (CO2) emissions emitted over a period of time to keep Earth's temperature within a certain threshold—these are a big cost for the climate. But as we'll discuss later, although operational carbon emissions from the building sector are at least being somewhat tackled, it's still not without carbon problems. For example, without accounting for embodied carbon, GHG emissions associated with materials used to lower operational carbon emissions can exceed operational carbon for years to come. Can we really get to global net zero carbon by adding more GHG emissions?

Figure 4: Embodied Carbon & Operational Carbon GHG Emissions Sources. (Sanska)

The carbon intensity of electricity plays a role in the GHG emissions associated with both embodied and operational carbon. In Canada, the generation, transmission and distribution of electricity falls primarily under provincial jurisdiction, with most provinces having publicly-owned utilities. Country-wide, hydro has the highest share of generation at 60%, followed by nuclear at 15%, coal at 7%, gas/oil/other at 11% and non-hydro renewables at 7%[18]. As each province's source or mix of sources determines the GHG emissions associated with the utility and its carbon intensity, there is a range of impact.

For example, Nova Scotia's electricity is "dirty" or high-carbon as it is primarily generated by burning imported coal mixed with petroleum coke, producing about 720 g CO2e/kWh (Figure 5). This means both embodied carbon and operational carbon are more carbon intense, or produce higher GHG emissions as well as other pollutants, in Nova Scotia as compared with regions with low-carbon electricity such as Quebec, Manitoba, British Columbia or Ontario.

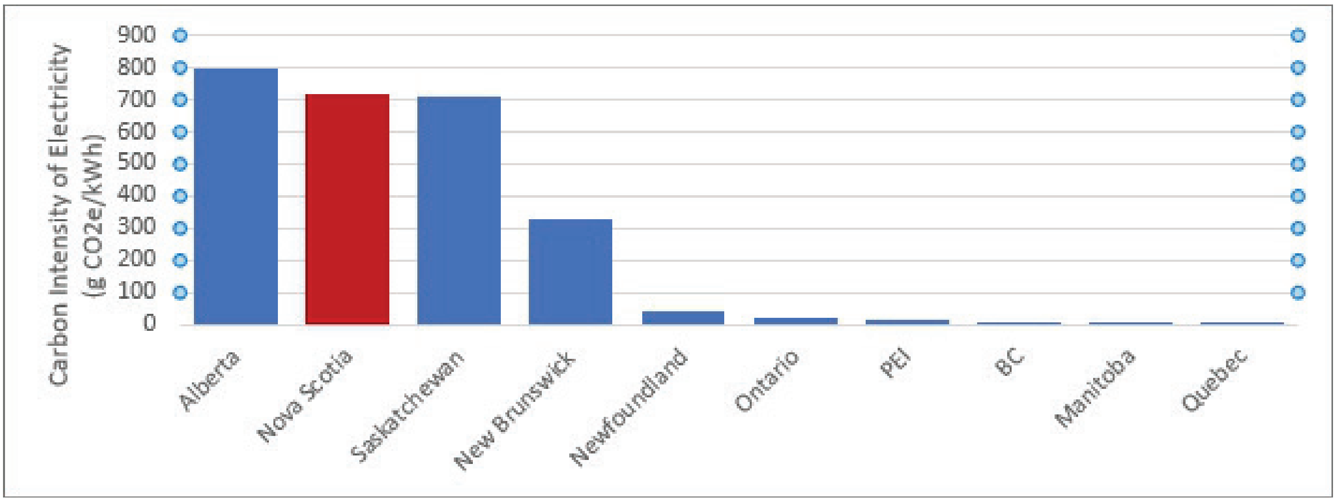

Figure 5: Electrical grid carbon emissions intensity by province (g CO2e/kWh)[19] (Mantle)

Plans exist to partially "green" Nova Scotia's grid, with the opening of the Muskrat Falls hydroelectricity project and with the addition of new solar and wind capacity by 2030. If its electrical production decarbonizes, carbon emissions generated by buildings can be significantly reduced through electrification. However, at this time these projected GHG emissions reductions remain uncertain, and a decade of carbon intensive electrical production is problematic for embodied and operational carbon and the climate.

Buildings are the carbon they ate. The understanding that buildings are a repository of all the energy that went into their creation is not a new concept[20], yet even so embodied emissions are often not included in climate scenarios as the focus has been and remains on operational energy. As buildings become more energy-efficient and energy sources decarbonize so the operational carbon is lowered, the relative portion of carbon emissions associated with the embodied carbon becomes increasingly significant. Embodied carbon is expected to be responsible for almost half of total new construction emissions globally between now and 2050.[21]

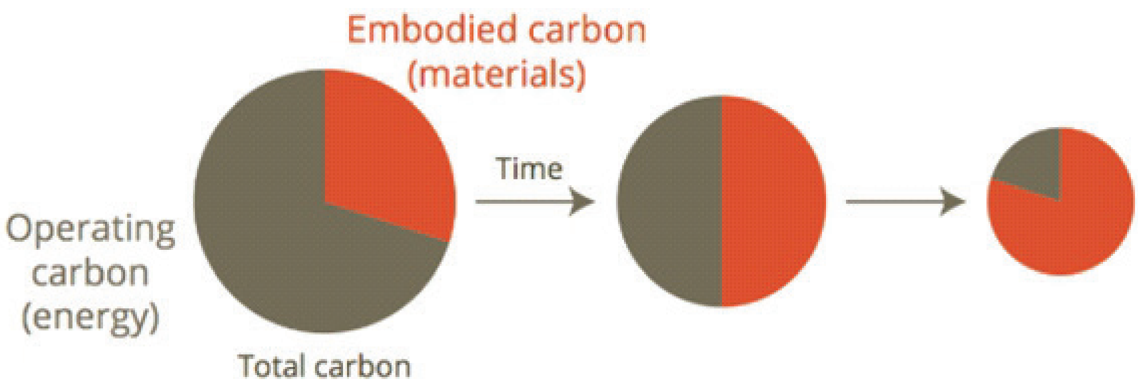

Figure 6: Importance of upfront carbon/embodied carbon as carbon intensity of operational carbon decreases.(Pembina.org)

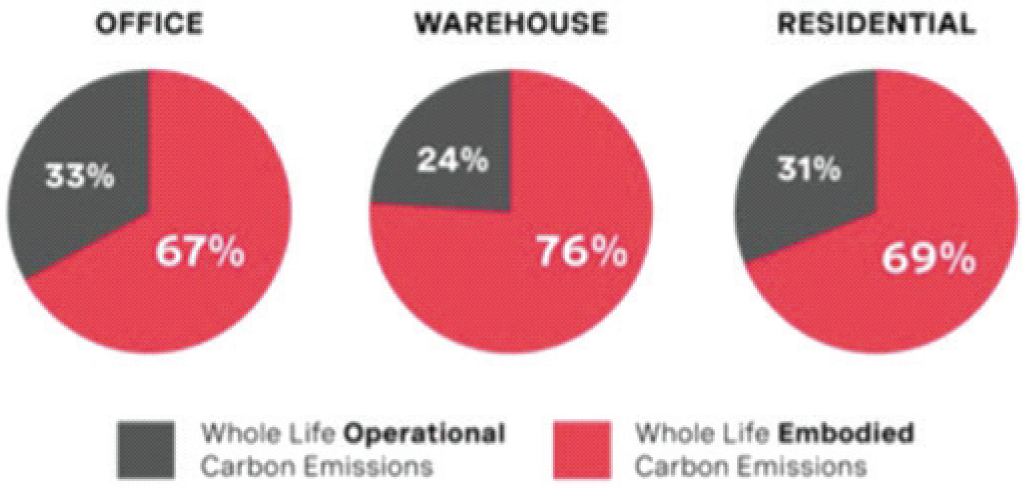

Figure 7: Embodied carbon emissions (in red) as a percentage of GHG emissions over lifetime of three building types.[22] (ACAN)

This hidden carbon footprint of buildings is the subject of several recent major studies that stress the urgency of reducing the embodied carbon emissions associated with the building and construction industry now.[23][24][25][26] Because the majority of carbon emissions associated with buildings are increasingly likely to come from this "hidden", primarily upfront source it is necessary that these be regulated such that building design and construction materials aim to achieve global net zero carbon.

Several options exist for reducing embodied carbon, including minimizing new materials, reducing waste, reusing existing materials, choosing low-carbon materials, using modular or prefabricated components, maximizing recycled content, and efficient building density and scale. As well, biogenic materials such as wood, straw, bamboo, cork, sheep's wool insulation or hemp are often the least carbon intense, and with good policies to ensure sustainable sources, can be carbon sinks. As this sequestered carbon is stored and kept out of the atmosphere during the lifetime of the building, the end of the lifecycle of the building is an important factor.

Iron, steel, aluminum[27], cement production, petrochemical-based and rubber materials are examples of some of the most carbon-intensive materials used in building and construction. Their emissions intensity cannot be reduced just by using cleaner energy or recycling, but require material efficiency strategies or new technologies that may take decades to achieve.[28]

In 2019 Canada was the top producer of waste in the world at 36.1 tonnes per person each year.[29] In most developed countries, 30-35% of the total waste generated is from construction, renovation and demolition processes but in some countries, it may be as high as 90%. Planning and design to reduce embodied carbon can be an opportunity to re-set societal consumption patterns.

Canada's present-day waste reduction focus on the "three Rs"—reduce, reuse and recycle—weights each of these solutions equally. But over-reliance on recycling is a band-aid, treating a symptom of materials overconsumption. It ignores the most socially responsible and cost-effective solutions of avoidance, prevention and reduction that can be implemented in a cradle to cradle or zero-waste principle rather than the present-times linear pattern of production, consumption and disposal. Effectively, such a necessary change in attitude, supported with regulations and policies, can address the role of embodied carbon in the climate crisis.

Some governments, policy makers, professionals and the construction and building industry [30] are starting to address this embodied carbon cost, but not in a timeframe that reflects the knowledge of the industry's impact or the urgency of the climate crisis[31]. Globally, we need to reduce material use and re-examine the type of materials used in order to make better choices, starting now.

Canada, Codes and Building Carbon

Canada's National building code ignores embodied carbon and operational carbon. These emissions do not fall directly within the existing priorities of our national model codes, despite increasing awareness of both the sector's and the public's desire to address these two areas. The Canadian Commission on Building and Fire Codes (CCBFC) priorities are: safety, health, accessibility for persons with disabilities, fire and structural protection of buildings, and the environment. Carbon in either form, embodied or operational, can theoretically fit into these priorities and is a goal of some, however, the CCBFC and committees involved do not necessarily share this view and energy efficiency remains a higher goal.

> "The CCBFC recognizes that implementing a national carbon-free economy will provide a more comprehensive assessment of the broad impact of energy efficiency measures. However, until all levels of government agree on an approach for a national carbon-free economy, the long-term performance goal for buildings should focus on energy—not carbon.[32]"

Developing requirements for a carbon budget that includes embodied carbon, and net zero energy building codes for energy self-sufficiency to ensure buildings are ready for a low-carbon future is necessary and most likely to occur at the provincial level. Although a number of green building certifications and rating systems exist[33], these have a variety of standards for materials and may only model rather than track operational data once a building is constructed. Overall, because their adoption is voluntary, these remain insufficient to ensure widescale GHG emissions reduction.

Building for a low-carbon future and climate resilience can no longer ignore the need to be regulated, with defined timelines and targets for GHG emissions reduction. This can be beneficial as it will reduce capital and operational costs and environmental impact and risks. As we take steps to remove carbon pollution from our atmosphere, we need to get beyond Canadian-style climate crisis rhetoric, with a measurable commitment to reducing embodied carbon in building and construction.

Canada's GDP[34] is heavily weighted to reflect economic activity in industries such as construction (7.07%) and manufacturing (10.37%) as well as related businesses such as finance and insurance (7.07%), and real estate, rental and leasing (13.01%). Together these comprise 37.52% of the GDP (2017). Unfortunately, conventional measures of wealth and growth do not factor in the cost or benefits of this economic activity to society, the environment or the climate. Cradle to grave economic growth with a linear pattern of extract, produce, use, discard remains the modus operandi.

Measures for full-cost accounting such as found in a cradle to cradle or circular economic pattern would demonstrate the limits of our present-day economic analyses.

For example, in the Nova Scotia context adopting the precedent-setting Genuine Progress Index Atlantic or GPI Atlantic[35] would change what gets counted. This full-cost accounting would indicate the real benefits of a shift away from fossil fuels and waste in the demolition, construction and building sector in a more direct way—especially environment, health and well-being. Or to be less esoteric and directly pragmatic—jobs. Studies show that residential rehabilitation creates 50% more jobs than new[36] construction and uses about half as many materials. If we measured the real cost to and of the climate crisis in our economic accounting would we continue to long for a return to normal post COVID?

Vancouver is one Canadian city that through political leadership has acted early to reduce overall carbon pollution by 50% by 2030. Many of its policies and initiatives can serve as a template for other jurisdictions. To address carbon in the building sector it will transition to Zero Emissions Buildings by 2030, will forbid new natural gas installation and is developing neighbourhood renewable energy systems for centralized heating, hot water or cooling[37]. It has adopted requirements for high performance/Green building standards (Passive House and Net Zero Energy) to meet by-law energy requirements, rezoning conditions and discretionary zoning variances.

Vancouver’s Climate Emergency Response (2019) set a target to reduce embodied carbon in new construction by 40%. Its Climate Emergency Action Plan (2020) includes a road map to achieve this over the next 10 years. Estimates for embodied carbon have been required since 2017, and initial requirements to reduce this upfront carbon in new construction will be recommended to Council in 2021.

The city’s recent building bylaws allow taller wooden buildings and have eased barriers to mass timber construction, (which unless sustainably harvested has its own climate problems). It also incentivizes deconstruction and material reuse over demolition to reduce waste and support character retention.

Case-study Part I

Halifax's Carlton Street block is a centrally located small-scale, mixed-use area on Halifax's South Common near Camp Hill Cemetery, the Public Gardens and Dalhousie University's Carlton Campus. Approximately 22-25 multi-unit historic buildings on the block are 100+ years old. Fifteen houses on two sides of Carlton Street have individual and collective Heritage Designation at the federal, provincial and municipal levels as a "rare early Victorian streetscape."

Map 1: The "Carlton Block" bounded by Spring Garden Rd., Robie, College and Carlton Streets has approximately 25 buildings in total.

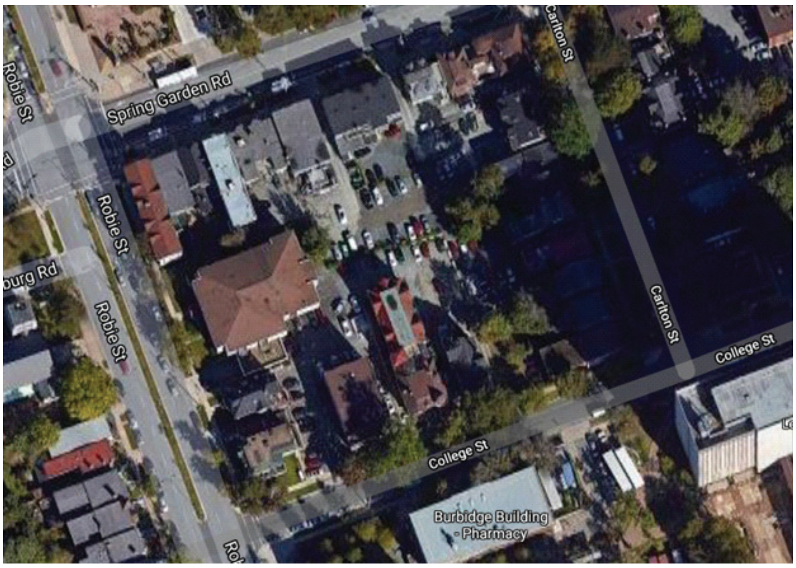

Image 2: Carlton Street block neighbourhood (Google Map)

Initial public consultations as part of the city's new Centre Plan process proposed adding 400 residents to the area with two 10-storey and one 5-storey buildings or one 10-storey and three 5-storey buildings. It did not consider an 18-storey tower approved for the northeast end of Carlton Street.[38]

But now two developers with two proposals planned for less than the single block are advancing through the city approval process—separately and despite public opposition. In fact, under the new Centre Plan the area is now designated for 90m or 30-storey buildings.

The Rouvalis proposal, "The Promenade," is for 28- and 29-storey towers + penthouses (previously approved for 20 and 26 storeys) with six floors of underground parking containing 511 stalls (increased from 384). It will require the demolition at least four multi-unit buildings (three are historic) with 56 units and two historic buildings will be relocated and renovated.

Image 3: Rouvalis proposal The Promenade, as first approved 20- and 26-storey towers at Robie and College Streets.

Image 4: Rouvalis developers will cause the demolition of at least four buildings (Photos 1, 4, 5, 6) and restore two (Photos 2 and 3) in the Robie and College Street portion of the Carlton Street block. (https://bit.ly/3lx0blK)

The Dexel proposal, Spring Garden West, is presently for 16- and 30-storey towers (but may now be 30 storeys) with 380 underground parking stalls. Between 8-10 multi-unit historic buildings will be demolished. These contain 31 residential units and 22 commercial spaces. There is no policy for replacement of affordable units that will be demolished or requirements for mixed-income housing in the new buildings.

Image 5: Dexel's Spring Garden West as first proposed, was for 16- and 30-storey towers at Robie Street and Spring Garden Road. These are now permitted for 90m or ~30-storeys.

Image 6: Dexel developers want to demolish 8-9 buildings in the popular Spring Garden Road portion of the Carlton Street block to build two towers up to 30-storeys. (Photo: Alvin Comiter)

Image 7: Coburg Apartments, Spring Garden Road is a 19th Century “missing-middle” prototype and one of 8-9 buildings to be demolished for the Dexel towers.

Total preliminary embodied carbon emissions from the two Halifax Carlton block proposals are estimated to be in the order of 31,000 metric tonnes of CO2e. **Note,** This number does not include the estimated 160T from associated demolitions. Also, as the Rouvalis proposal has increased its tower heights from 20- and 26-storeys to 28- and 29-storeys plus penthouses, and the number of parking stalls from 384 to 511, the Dexel proposal may seek an increase in the tower heights and number of parking stalls. Therefore, these estimates for embodied carbon costs may be low relative to the final combined projects’ global warming gases.

Image 8: View of four towers (16-, 30-, and 20- and 26-storeys) as first proposed by two developers in less than a city block. (DOH) Heights are now all approved for 90m or ~30-storeys.

Activity	Estimated Construction (m2)	Embodied Carbon Intensity (kg CO2e/m2)	Embodied Carbon (t CO2e)
Total New High-Rise Construction	~73,000	360-490	~26,000 – 36,000
Demolition of existing	~10,700	15	~160
Relocation of existing	~2,200	5	~11

Table 2: Preliminary embodied carbon emissions estimate of Carlton block development. (Mantle)

What exactly is 31,000 tonnes of CO2e? This is equivalent to about 40 years of operational carbon from the existing buildings. Or the CO2e emissions from 9,497 passenger vehicles; consuming 13,206,189L of gasoline; 414 tanker trucks of gasoline; 7,260 homes' energy for one year; consuming 70,041 barrels of oil; or 1,291,667 propane cylinders used for home barbeques.[40]

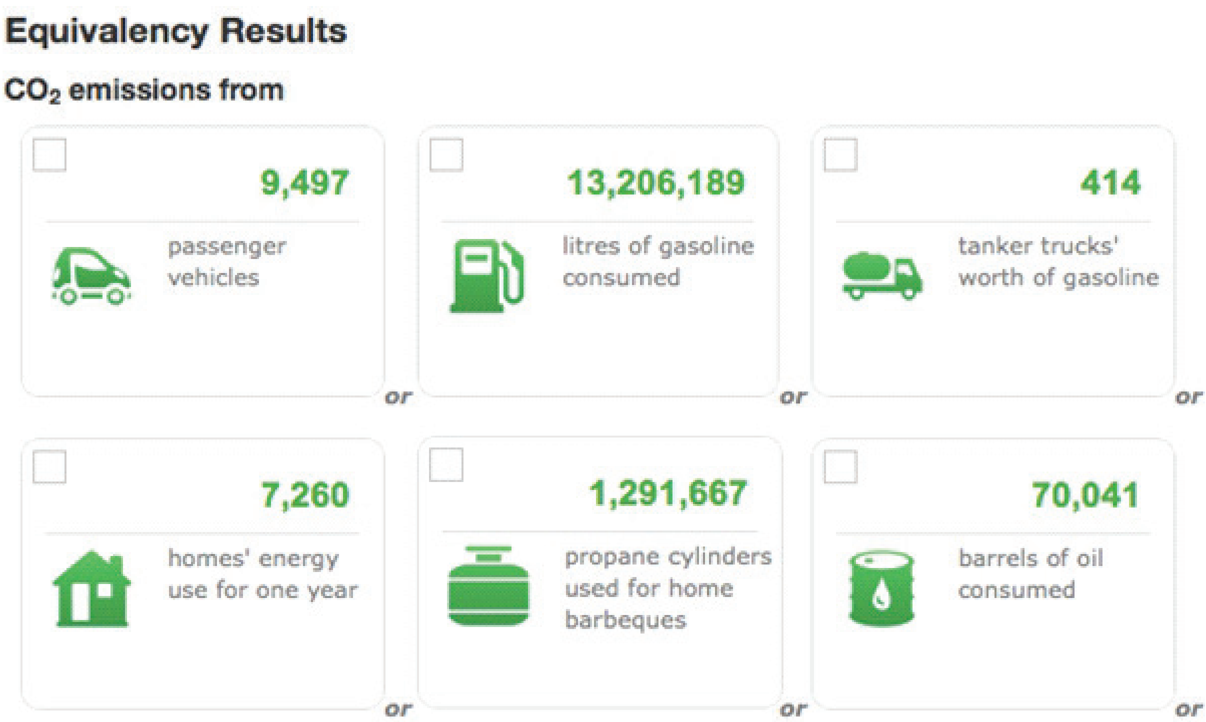

Figure 8: Embodied carbon impact of 31,000 tonnes of CO2e equivalencies according to the Government of Canada. (https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghgcalculator)

Seeing is believing. Large abstract numbers are hard to imagine or even relate to. Greenhouse gas emissions numbers may be worse because they're invisible. Barry Saxifrage[41] recently used relatable visual stand-ins to help convert invisible CO2 emissions to a more familiar form of pollution. What if we considered these 31,000 tonnes of CO2e emissions as littered plastic bags? A plastic bag weighs 6g, so it takes 165 to weigh 1kg. So, the 31,000 tonnes or 31,000,000kg upfront carbon from the two Halifax Carlton block proposals is equivalent to 5,115,000,000 or 5.1 billion littered plastic bags. Unimpressed? How about 62 billion littered straws?[42] Or if you've been busy baking your way through COVID maybe you can better imagine 68,343,301 (that's 68 million and a bit) pounds of butter?

Remember Nova Scotia's 2030 target is to reduce emissions to 11.5 megatonnes. As 2018 emissions were approximately 17-18 megatonnes that will require an emissions reduction of between 6.5 to 8.5 megatonnes. Clearly adding GHG emissions into the atmosphere of any magnitude is not the way to reduce emissions or meet targets.

Building scale is a significant contributing factor to the intensity of embodied carbon emissions as this determines both the type and the amount of material used for the structure. Table 3 summarizes the best available data on the embodied carbon intensity of low-rise (1-6 storeys), mid-high-rise (7-15 storeys), high-rise (16-25 storeys), and high-rise (25+ storeys) residential buildings, using concrete, light-wood frame, or hybrid mass timber structures. While acknowledging that each project is uniquely designed, comparing these values is a good starting point for considering upfront carbon cost and the consequences of various design options.

Taller buildings typically require more structural and foundation materials such as iron, steel, aluminum or cement products to ensure their safety and performance; as the building height increases, the embodied carbon emission intensity increases. Additionally, taller buildings commonly have more underground parking, which requires a large amount of concrete use and associated carbon. An initial analysis of the embodied carbon reportings submitted for the City of Vancouver's Green Buildings Policy for Rezoning[43], and a similar project at the University of Toronto, found that buildings' embodied carbon increases with higher ratios of concrete products and more levels of underground parking.[44]

The proposed Carlton Block developments will have at least ~891 parking stalls in three to six levels underground in an area where complications may occur because of underground streams. While this report does not cover the impact of such car-oriented buildings on GHG emissions or local air pollution/health in what is supposed to be a transit-oriented city, the reader should be aware that Canada has the worst vehicle efficiency (think big gas guzzlers) in the world.

Further, although this report is focussed on embodied carbon, high-rise residential and office buildings have higher operational carbon costs because of cladding materials and envelope systems that result in high heat transfer rates between the inside and outside of the building, and low thermal energy efficiency.

This energy transfer via envelope components tends to not be considered in modelling of building energy performance, so the building energy performance is overestimated compared to the actual efficiency. High window-to-wall ratios adds to lower energy efficiency and high energy demands in winter and summer[45]. In Halifax, recent developments favour glass-cladding.

Construction type	Building Height	Embodied carbon intensity (kgCO2e/m2)	Structure Type
New building	Low-rise, 1-6 storeys	170-260	Wood
	Mid-rise 7-15 storeys	270-360	Wood
		290-380	Concrete
	High-rise 16-25 storeys	250	Hybrid mass-timber
		310-400	Concrete
	High-rise +25 storeys	360-490	Concrete
Renovation	Not Available	120	Not Available
Demolition	Low-rise 1-6 storeys	15	Wood
Relocation	Low-rise 1-4 storeys	< 5	Wood – With a crane

Table 3: Average embodied carbon intensity of new residential buildings (Mantle)

"**Energy Use for Building Construction**[46]," a 1976 book by New York-based architect Richard Stein and researchers at the University of Illinois, Urbana-Champaign established early evidence on the environmental consequence of demolition. Research evaluated embodied energy of typical new building materials, building assemblies and building types of 1967 construction types[47]. Several studies compared embodied energy and operating energy of reuse of an existing building, remodeling a building and replacing a building[48]. Three scenarios found that "reusing an existing building to make it more energy efficient had an immediate savings of total energy use. If building new, no net savings of total energy are achieved until a future date that can be greater than the life expectancy of many new buildings." [49]

Assessing the carbon worth or value in existing buildings generally proves that extending their life through retrofitting, renovation, re-purposing, rehabilitation or adaptive reuse is a more cost-effective[50][51][52][53][54] & sustainable choice when compared to new construction. The Life Cycle Analysis evidence is in—the assumption that building new, more efficient buildings is the only way to address climate change is unfounded. The greenest buildings are already built; it can take between 10-80 years for a new "green" building that is 30% more energy efficient than the existing one to make up for the upfront carbon emissions unleashed during construction[56]. An economic bonus is that each $1 million invested in energy efficiency improvements generates up to $3 to $4 million in gross domestic product and 30-52 job years.[57]

The Ken Soble Tower in Hamilton is a recent Canadian example of the multiple advantages of retrofit, including reduced embodied carbon. After reviewing options including sale, rebuild, capital repair or rehabilitation of the 18-storey concrete tower, the best option considering cost, timeframe, and social disruption was retrofitting the building to EnerPHit—a Passivhaus retrofit standard. The analysis of the carbon impact of demolition vs retrofit found that a new replacement Passive House building would take 180 years to become carbon neutral.[58]

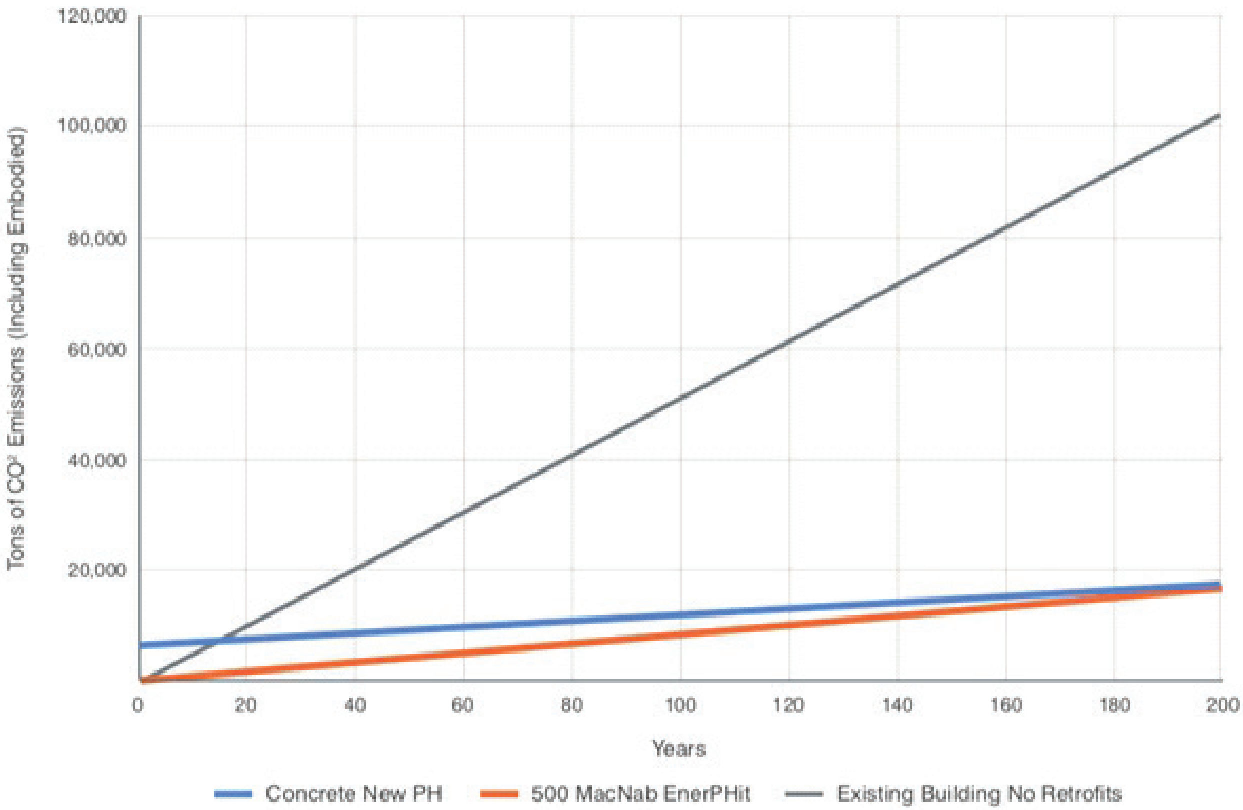

Figure 9: CO2 emissions of new concrete Passive House vs. retrofit of Ken Soble [59]

The advantage of the retrofit's new built-in resilience to extreme weather is that the highly insulated building can remain comfortable for up to four days during a power outage compared to four hours in a building built to Ontario Building Code requirements. That's to say nothing of the reduced operational impact and cost for the residents of these affordable housing units!

The Carbon Cost of Demolition

What would a carbon crisis lens reveal about the two proposed Halifax developments that isn't being seen at present? In total 12-14 buildings containing 87 housing units and 22 commercial spaces (100~110 units total), an area of approximately 10,300m2, will be demolished. For comparison purposes, the Canada Green Building Council defines a low-rise multi-unit residential building (MURB) as being a four-storey building of 3,135 m2. As these two proposals will demolish an area greater than three such buildings, let's look at what the carbon cost would be to replace this same area. After all, isn't that what we'd do if we treated carbon as a commodity?

What is the carbon cost of demolition replacement? Based on the average embodied carbon intensity of new residential buildings (Table 3), the carbon cost to replace the Carlton Block's demolished buildings with an equal area equivalent to 10,300m2 of three low-rise (4-storey) wooden structure buildings would range from 1,751 tonnes CO2e to 2,678 tonnes CO2e. This is the lowest carbon intensive option with an average of 2,214 tonnes CO2e.

Carbon intensity increases with the increased height of the buildings. For a single mid-rise (12-storey) wooden structure replacement building the range would be from 2,781 tonnes of CO2e to 3,708 tonnes of CO2e with an average of 3,213 tonnes CO2e.

Construction type	Replacement Building	Embodied carbon intensity (tonnes CO2e)	Structure Type
New building	Low-rise, 4-storey (3)	1,751 – 2,678 Average 2,214	Wood
	Mid-rise 12 storeys (1)	2,781 - 3,708 Average 3,213	Wood
		2,987 - 3,914 Average 3,347	Concrete

Table 4: Average embodied carbon intensity of 10,300m2 replacement structure (Mantle)

The embodied carbon cost to replace the demolished buildings' area equivalent of 2,214 tonnes of CO2e according to the Government of Canada is comparable to CO2 emissions from 678 passenger vehicles; consuming 943,178L of gasoline; 29.5 tanker trucks of gasoline; 519 homes' energy for one year, consuming 5,002 barrels of oil; or 92,250 propane cylinders used for home barbeques.[60]

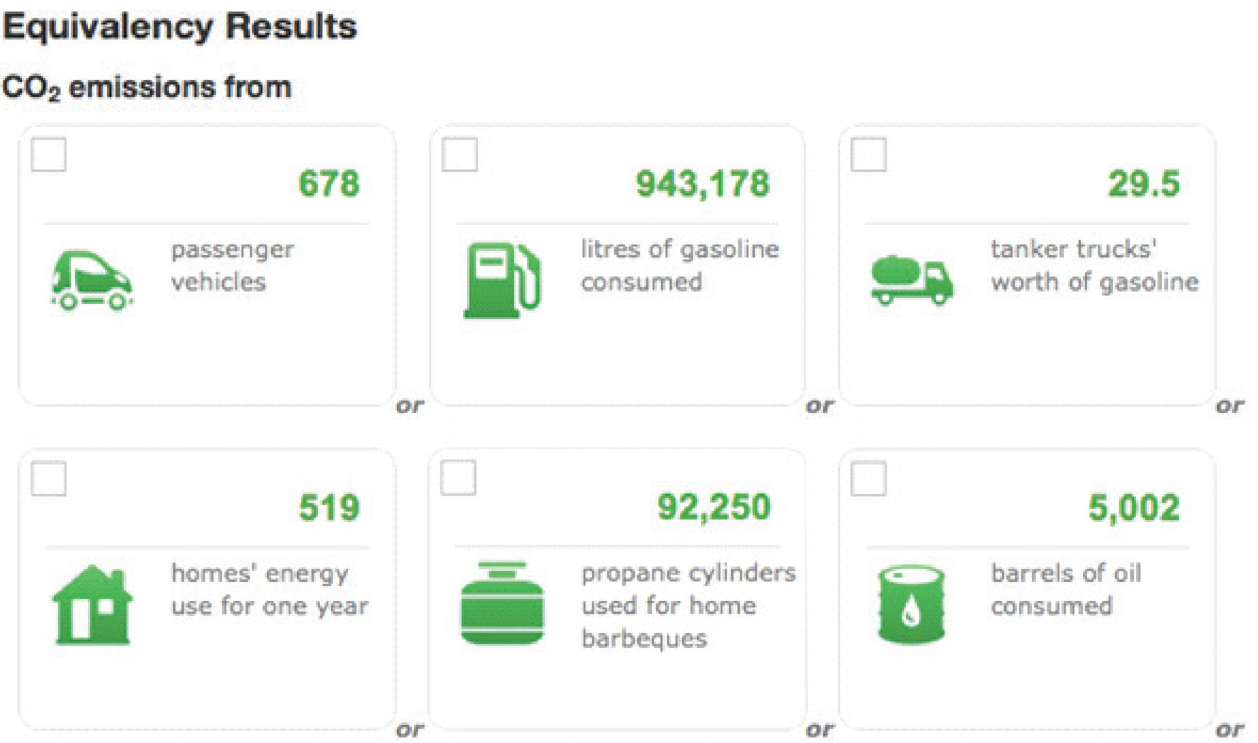

Figure 9: Average embodied carbon impact of lowest carbon intensity replacement structure equivalencies according to the Government of Canada. (https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghgcalculator)

A litter look at 2,214 CO2e tonnes of pollution if we could see it would be equivalent to throwing away 365 million plastic bags. That toss is about 376 bags per Nova Scotian. Or just 74 bags short of the 450 plastic bags per citizen[61] that used to get sent to the landfill each year and motivated the Nova Scotia government to pass the Plastic Bags Reduction Act and ban single use plastic bags in 2020. This unnecessary carbon cost to replace the wasteful demolition of existing building area in this single Halifax block is not just a cost to the climate but to all of society.

The habit of demolition goes deep into our way of doing business. Between 2003 and 2020 Halifax issued 2,535 demolition permits[62]. Although the overall average is 141 buildings per year, the number of demolition permits per year has increased steadily, reaching 188 in 2020.

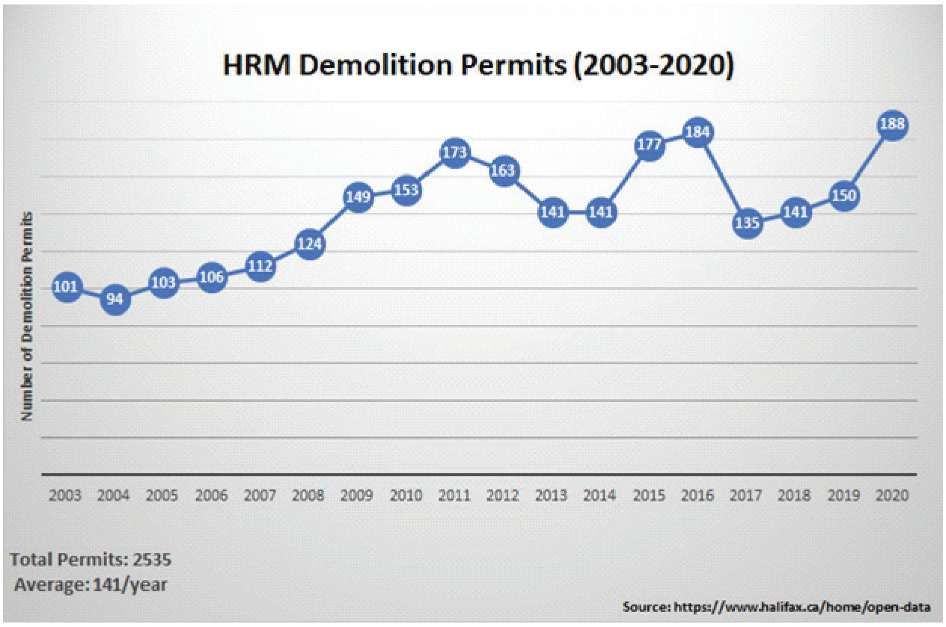

Figure 10: HRM Demolitions Permits (2003-2020) total 2,535, estimated to be equivalent to an area of about 17 city blocks.

There is no public record of the size or type of buildings that are being demolished, but for perspective on these numbers, assuming an average unit/house size of 1,500sqft[63], this is approximately equal to 3,802,500sqft (353,263m2), a floor area of ~17 city blocks.

Image 9: Seventeen city blocks (250,000m2), is equivalent to the area bound by Quinpool Road between Monastery Lane and Vernon St, south to Coburg between Chestnut and Vernon. LeMarchant – St Thomas School is in the centre.

The 2,535 demolitions is almost the same number of demolitions that occurred during Halifax's "urban renewal" or slum clearance period between 1958 and 1965. At that time in the downtown Cogswell area, 2,539 buildings were demolished[64]. Today this is still viewed as a huge social, cultural and economic disruption to the city that is still not repaired. Another comparison is the Halifax Explosion which destroyed approximately 1600 homes.

Tools and methods to quantify this embodied and largely up-front carbon value or carbon worth of existing buildings as compared to the carbon cost or environmental impacts of new constructions exist[65]. One example is Canada's own Athena IE, North America's only free, open-source Impact Estimator for Buildings. It was developed by Athena Sustainable Materials Institute in 2002, with regular updates to be used by design teams to analyze the life cycle environmental footprint of various material and core-and-shell system options.[66]

In a world where we need to immediately both reduce and remove GHG emissions, is it time to calculate an embodied carbon penalty for building a new building instead of finding ways to continue to use one that is already there by retrofitting, renovation, repurposing or adding on? Why should 2,214 CO2e tonnes of unnecessary pollution that harms us all be freely permitted and unregulated? We must change the economic model that only considers the value of what is being demolished as a sunk cost, and account for it by calculating the upfront carbon cost of its replacement. That is the only way we will start to avoid unnecessary climate impacts from unnecessary demolition.

Why is Embodied Carbon Ignored?

Factors that limit action to reduce up-front carbon emissions are numerous, but perhaps the biggest one is that the primary carbon focus has been on the operational side. With energy efficiency as the proxy for carbon, efforts to reduce GHG emissions with energy efficiency or demand-side management are the most palatable as people can be motivated by financial savings through reducing energy use and greater physical comfort. As well this is more easily managed and targeted for reductions because it is easily quantified through monthly energy/utility bills. Historically, in face of rising energy costs, governments have been more easily able to implement policies and programmes for operational energy efficiency. Ironically, whereas past efforts at energy efficiency were aimed at keeping heat affordable, as the climate warms many buildings will have increased cooling demands. In any case, measures to improve energy efficiency have not come close to cancelling out the rise in energy demands.

New construction energy efficiency is generally accomplished by design and a choice of materials that are from the outset viewed to have better outcomes for sealed and insulated and ventilated buildings. Dollar cost and the availability of the materials rather than their carbon cost is a primary reason for product selection. Confusion over product choice is increased by the wide range of building certifications, training and ethics. As described earlier in this report, it is a problem that, without attention to and accounting for the embodied carbon cost of materials, the energy intensity of a new build or retrofit can outstrip or delay the balance between energy spent and energy saved for years into the future.

Retrofits for existing buildings for basic energy efficiency gains generally focus on air sealing, insulating and installing mechanical ventilation. As with new construction, the cost and availability of materials are primary factors in materials choice, not their carbon footprint. Building owners often have built-in expectations for a short-term payback, and beyond a certain dollar value and timeframe (six-nine years) the future benefit is discounted, even though a refurbished building can last for 50+ years[67]. So too with developers who can pass the operational cost on to the tenant, or intend to sell a building or plan to demolish a building in the future as part of a redevelopment. These factors are also at play in deferred maintenance, whereby building owners make money but don't maintain or repair their asset as this suits a long-term objective of demolition or resale. Imagine if the majority of building owners would be so cavalier about their personal homes.

Carbon budgets with caps for new construction present an opportunity to reassess the economics of retrofits or even general building maintenance as the future value is not in redevelopment. The Dutch initiative Energiesprong[68] relies on economies of scale to transform multiple existing houses, using prefabricated or modular components, into net-zero buildings,

using money from energy savings and reduced maintenance costs. But without careful design and materials choice, building renovation can reduce, negate or delay the environmental benefits.

Construction materials have different associated carbon footprints. It is often possible to find an alternative to high-embodied carbon materials at a comparable or equal cost. There are several factors that impact a material's embodied carbon profile. These include whether the material is engineered or natural, the energy intensity of production, the amount of recycled content it contains, its durability, required transportation distance, and end-of-life recyclability. As much as 80% of a building's total embodied carbon is released during the manufacture of construction materials. That's why it is important to choose durable materials with a long-life expectancy to minimize replacement.

Accessing standardized information for carbon cost of materials or products so better product selection can be made can hinder choice. But efforts to develop and update baseline materials and products indexes to evaluate carbon emissions over their lifecycle, with third party review or audit, are growing.[69][70]

Environmental Product Declarations (EPDs) are one standardized example that determines and indicates the environmental impact of a product and can help with making the better choice. As there are various programme operators, standardized product category rules and consolidated or harmonized datasets are needed. Product Carbon Footprints (PCFs) is another standard to help limit or reduce the climate change impact by quantifying the environmental impact as part of a life cycle assessment (LCA), and to guide the design of products (material, production, transportation, use, disposal).

Databases of products and materials with such standards are becoming increasingly important, and they are more available and more comprehensive, but government leadership and regulations are urgently needed to support both innovation and de-carbonization and to regulate/require sustainable material use. For example, product labeling with carbon footprint information is one strategy that can influence purchase choice[71]. Such basic information about embodied carbon can be misleading because different products serving the same purpose may have different densities or require different quantities[72]. That's why carbon intensity information for all products and materials needs to be standardized and required.

Availability of low-carbon materials or products is increasing but without regulations or incentives their choice is still the purview of early-adopters rather than broadly used. Biogenic materials such as timber, cross-laminated timber (CLT) or glued laminate timber (glulam) or hempcrete, contain sequestered carbon and during the life of the building, this is stored and kept out of the atmosphere. Some products such as hempcrete can have multiple advantages for the correct context such as insulation value, anti-mold, vapor permeable, light weight and store carbon. Bylaws that permit the use of such materials are necessary to encourage use but not sufficient. In promoting products that sequester carbon one needs to consider the life-span and life-cycle of the building as well as the source and sustainability of the material or product.

Building structure and enclosure are the main contributors to embodied carbon. Concrete, steel, insulation, aluminum and wood are typically the most used materials in building construction. Other than wood these all are or may be particularly high in carbon. For example, Canada has recently banned extruded polystyrene (XPS) insulation because of its extremely high global warming potential; however, “next best” choices can still augment the climate crisis as shown in Figure 11.

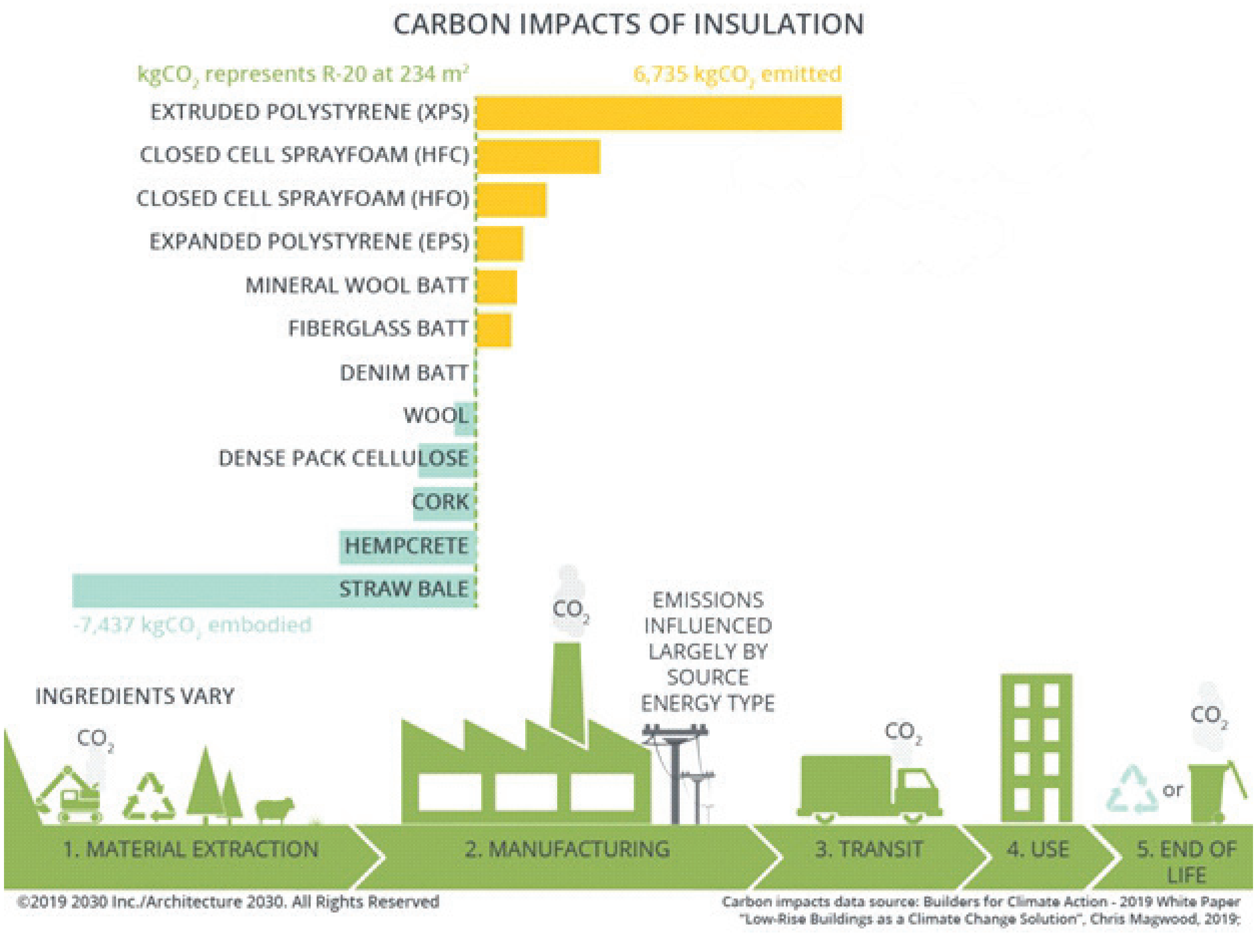

Figure 11: Carbon Impacts of Insulation [73]

And not all concrete, aluminum or steel is created equal. There are options available from design teams to minimize the carbon footprint of each of these materials. For example, specifying steel with a high amount of recycled materials (90-100%) can result in a 75% reduction in the carbon footprint compared to steel made from virgin (non-recycled) inputs. Similarly, the production of aluminum is highly energy-intensive and its use in window-wall systems has a significant climate impact. But as there isn’t enough recycled aluminum to meet demand, it is critical to use lower carbon products.

Concrete is the world's most widely used building material. Its production has expanded massively since WWII. It is one example where attempts to reduce its upfront carbon cost is not occurring at a rapid enough pace. Pollution and energy use associated with quarrying and processing are huge, as is the environmental impact from cement production, "the glue" that is used to bind sand, gravel and water into concrete. The industry has been addressing the carbon emissions primarily by improving energy efficiency, but still world cement production generates 8% of the global CO2 emissions. For context of its scale, the US at 11% is the second largest emitter of GHG.

Concrete can have 10-40% less carbon than traditional mixes with minimal impact on cost and performance using low-carbon cement, like Portland-limestone cement, supplementary cementing materials, typically bioproducts of industrial processes, and high amounts of recycled content. Concrete elements that do not require early strength can have even more carbon reduction using a higher percentage of supplementary cementing materials and allowing them to cure over a longer period of time (for example, over 56 days instead of the standard 28 days).

As the industry works toward decarbonizing, more innovative concrete alternatives with lower embodied carbon are being introduced. One example, CarbonCure, is a Nova Scotia-based business that has developed a process for chemically sealing CO2 within the concrete by injecting it into the wet concrete mix. According to the manufacturer, CarbonCure's technology can store roughly 400 kg/m3 and 400-640 kg/m3 of CO2 within ready-mix concrete and precast concrete, respectively. [74]

Low-carbon cement has the potential to reduce emissions by 2050 by 6%, and some jurisdictions are mandating carbon-injected concrete, but regulation, targets and timelines to reduce and limit emissions and cumulative impact, along with committed government support for research and development, are needed immediately for fast transition or to make any impact[75] . Waiting for the magic of future technology is not an option and we must focus on the most cost-effective ways to cut GHG emissions now.

Building typologies or archetypes have different associated climate costs. Large scale scientific studies of the embodied carbon costs of buildings do not seem to have been conducted in such a way that the data on typical magnitudes and ranges for different building archetypes or designs are known or certain in a standardized way. Data that is available is not necessarily of similar scope, or reliable and comparable within or between data sets. For example, definitions are not standard; a building area may be for gross, internal or exterior, in metres, feet, cubic or square etc.[76]

Even so, research does show that the average value of estimated embodied energy of buildings that are seven stories or higher is approximately 50% higher than the average for low-rise residences[77][78]. Ignoring the available evidence on the carbon cost of choosing the wrong building typology is a driving factor in the climate crisis. As noted from the case study, the structure complexity of increasing height causes embodied energy intensity to increase substantially.[79]

Additionally, building design can add to the carbon impact. In general, the more elaborations, whether by choice or regulation, the more carbon. For example, step-backs, most often a zoning requirement, increase the embodied carbon impact because of “more complicated structures to accommodate different floor plate configurations on upper floors—particular in mid-rise projects,” and for this reason should be reviewed and weighed against other impacts.[80]

Increasing height also increases operational carbon. “When rising from five storeys and below to 21 storeys and above, the mean intensity of electricity and fossil fuel use increases by 137% and 42% respectively, and mean carbon emissions are more than doubled…Newer buildings are not in general more efficient.[81]” For example, in general towers require more cooling, fan energy, lighting, and water systems on an area-normalized basis than do low-rises[82]. Table 5 illustrates this point with data on the operational carbon emissions of typical low-rise and mid-rise multi-unit residential buildings in Halifax, using the grid’s current carbon intensity.

Energy source	Emissions factor ($kgCO_2e/m^2.yr$)
Low-rise Multi-Unit Residential Building[84]	58
Mid-rise Multi-Unit Residential Building[85]	70

Table 5: GHG operational emissions intensities by building type for new construction in Halifax, Nova Scotia[83] (Mantle)

Planning for Density—Really?

Urban planning history is a patchwork of ideas and intentions to solve city design problems, but it is subject to disparate influences such as economic growth and surplus capital, the automobile, fear of disease and crime, racism, classism, slum clearances or urban renewal, gentrification, densification, developers' desires and creative destruction. Such factors determine city shape and size, and different eras have different trends or themes.

Presently, as with many Canadian cities, Halifax planners are focussed on urban densification through re-development with higher buildings as the chosen urban form. This is to counter the earlier 1970s planning trend of developing bedroom communities and intensifying road networks to have workers commute to the city for jobs and home to the suburbs. But densification without considering the climate crisis and the need for immediate emissions reduction is destructive, wasteful and harms us all.

The pattern of high-density developments on small parcels of urban land and low-density subdivisions on the edge of the city so prevalent in recent years has contributed to the "tall and sprawl" phenomenon. Increased municipal infrastructure and service costs; longer commute times with greater GHG emissions; housing unaffordability; fewer options for families; displacement of low-income and essential workers; mismatch between population density and services (schools, transit, health and community services and parks and recreation); and impact on natural ecosystems next to cities—these are some of the downsides of tall/sprawl.[86]

Research shows us that contrary to what the general public and many professional architects and planners believe, it is not necessary to build higher in order to raise density. It is often possible to achieve the same densities as tall, freestanding towers with lower-rise buildings designed in different forms and with greatly reduced embodied and operational energy.[87]

Right now, densification is being pushed as it is meant to solve multiple problems such as housing and commercial space demand, and ease infrastructure costs and the impact of city living on the environment, especially transportation congestion and emissions. But what if the side effects from focusing on high-rises are worse than the cure, and don't achieve the objectives?

Density done right[88] a report by Ryerson University, identifies many advantages to pursuing small scale developments throughout urbanized areas rather than in concentrated high growth nodes. These include improved livability and economic vibrancy of neighbourhoods, affordability, reducing emissions, better housing options—especially diverse "missing middle" housing to meet differing income and generational needs—and faster, cheaper, less-disruptive construction.

This “missing middle” housing includes medium-density multifamily options as alternatives to high-rises or single-detached houses such as two- to four- storey midrise buildings, duplexes/triplexes, stacked townhouses and townhouses, in fact similar to what the proposed developments will demolish. As we’ve shown, this smaller scale has more potential to reduce embodied carbon by using low carbon materials or products and have better operational outcomes. The style of densification matters; because distributed density does not need or rely on demolition and disruption or result in imposing and looming buildings, it has better acceptance. And with technical tools such as 3-D models, public consultation processes can help to identify the best locations for such in-filling. How can this work for Halifax or other Canadian cities?

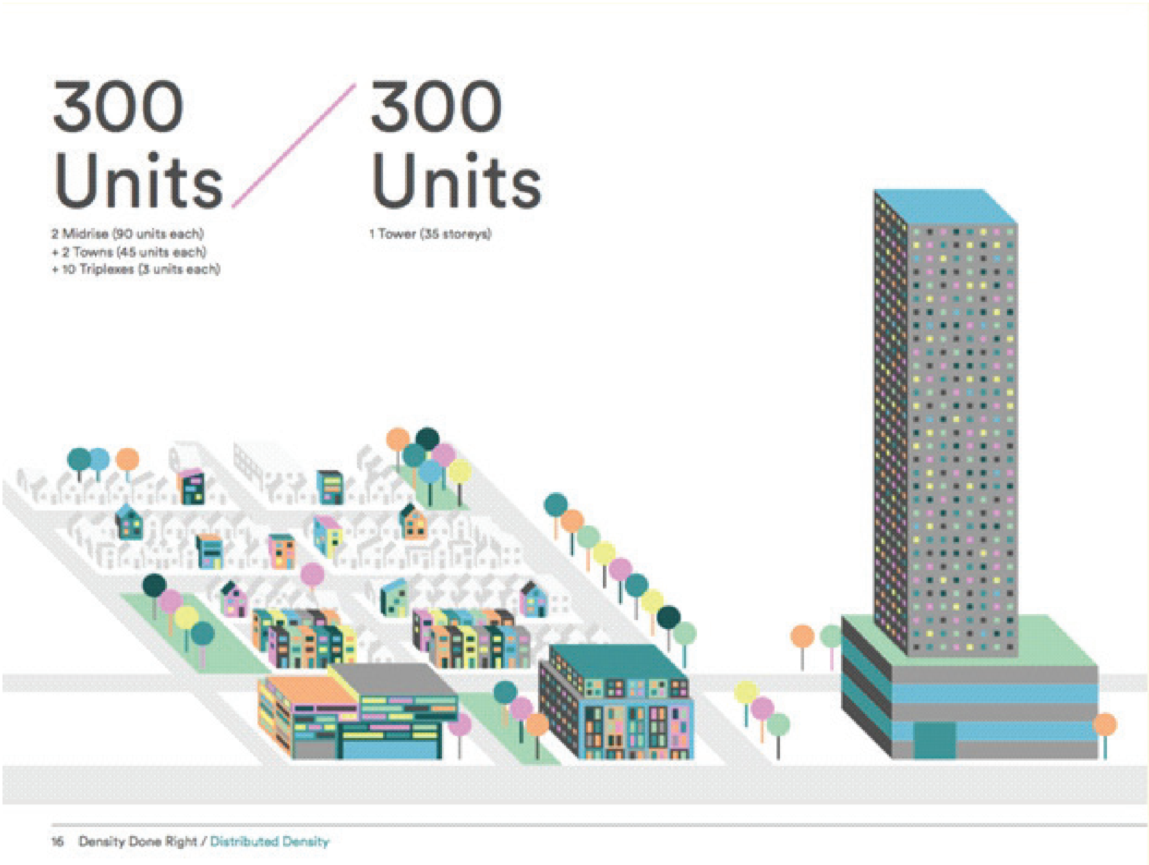

Figure 12: Density done right with 300 units in missing middle options vs high-rise[89]

In Halifax a 2013 Stantec Report commissioned by HRM found there is enough capacity within the Regional Centre for 35,000 additional units without changes to the Regional Plan. Pursuing distributed density instead of tall/sprawl could be achieved through this existing capacity, by in-fill or further augmentation, by converting existing single-detached or semi-detached buildings into multi-family buildings with three to five units. While the population of the Halifax Regional Municipality, an amalgamation of Halifax, Dartmouth, Bedford, Sackville and the former Halifax County is growing, as the fourteenth largest municipality in Canada, estimated by Statistics Canada to be 448,544 (2020), and the thirteenth largest metropolitan area, it still a relatively small.

The Halifax-Based Willow Tree Group's[90] **preliminary analyses** provide further evidence there is another way to achieve densification. This citizens' group estimated that mid-rise (five-storey) development along Quinpool Road, a centrally-located main street, would allow for 2,500–2,800 new bachelor, 1-, 2- and 3-bedroom residential units. This approach would enable Quinpool Road to benefit from a greater number of residents on the street without the drawbacks associated with blockbusting high-rise projects. It would also mean that a large portion of development capacity isn't centralized in one location or with one developer. Instead, more property owners/developers would be able to capitalize on the development potential of the street; truly a distributed density. And with careful planning carbon neutral or draw-down.

An adaptive approach for densification of a Halifax neighbourhood taken in a recent 2021 Dalhousie University M.Arch thesis confirms that accommodating more people can be achieved by working with what's there. It uses a series of in-fill projects and third-story additions to show the potential of middle density development that avoids demolition. With a modest implementation of 1- 2- and 3- bedroom residential units, a block can increase its population by 40% without going over three storeys and maintaining 40% green space. This approach can create homes for 66 new households of 76 new residents and add 42 new integrated work units to the single block without dramatically altering the look and feel of the neighbourhood. And by avoiding land assembly and demolition, the increased capacity is cheaper, faster, carbon neutral and not dependent on the high-rise.[91]

Land use efficiency and densities can be assessed by looking at the Floor Area Ratio (FAR) of different dwelling types. This is the ratio of the total gross floor area of a building divided by the total lot area. The asymptotic curve in Jack Diamond's graph (Figure 13) expresses the great savings in land when you increase the FAR from 0.25 (for single-family dwellings) to 0.5 for townhouses, 1.0 for stacked row housing, and 1.5 for low-rise apartments. As densities increase to 0.75, so do savings in land, but less dramatically. Once a FAR of 1.5 is achieved, there is very little advantage in terms of land use[92]. A 1.5 FAR is also the "sweet spot" for supporting public transit and other urban amenities.[93]

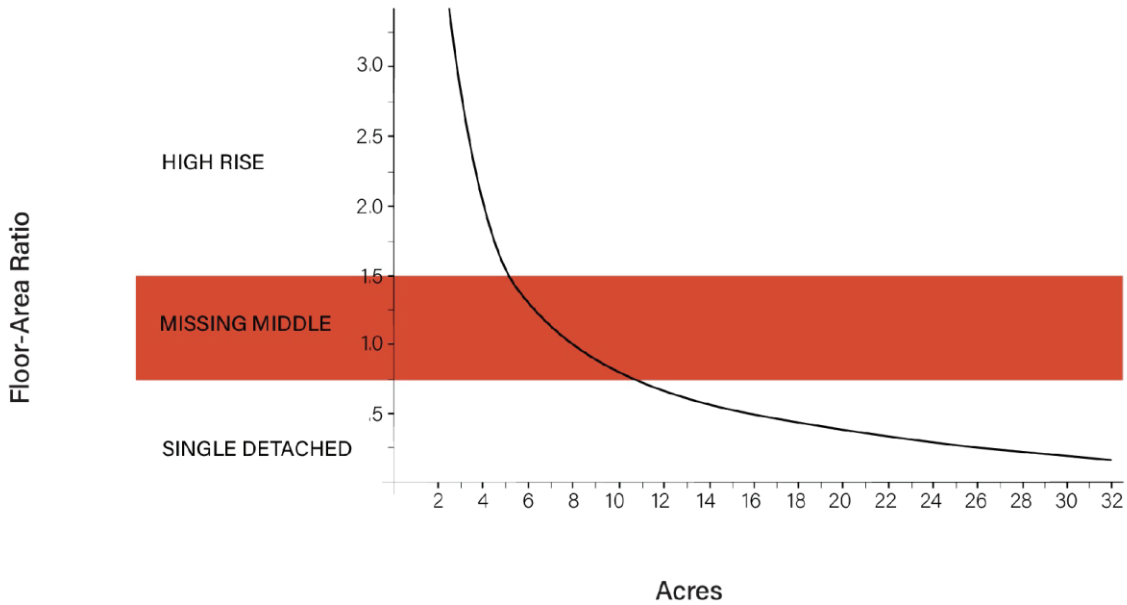

Figure 13: Assessing land use efficiency and densities using Floor Area Ratio of different dwelling types.[94]

Case-study Part II
Halifax's Carlton Street Block

Since the need or success of high-rises is debatable and the associated GHG emissions harmful, it is particularly important to examine the impact of built form design choices on carbon emissions,[95] and ensure that themost sustainable design choices aremade.

As shown in Part I of the case-study, the Halifax Carlton block proposals for four towers will emit 31,000 tonnes of embodied carbon— equivalent to 5.1 billion littered plastic bags. The embodied carbon cost to replace the area of the demolished buildings alone is 2,214 tonnes, or 365 million plastic bags, freely and without penalty. You'll remember that Nova Scotia has banned plastic bags for just under this amount of pollution.

A group of Halifax citizens, Development Options Halifax (DOH), have visualized the space available for an in-fill within the block with a goal of minimizing the demolition of the existing buildings. The volume of this space could hold a variety of design interventions—green terraces, commercial space, or detached residences of larger multi-unit buildings to increase permeability. The pink massing displayed in these images (Figure 14) reflects the shape of a schematically designed nine-storey multi-unit in-fill with an approximately 6,300m2 building footprint.

Comparing this mid-rise option with the developers' proposed high-rises supports the public and decision makers to be better informed when joining the discussions on the development.

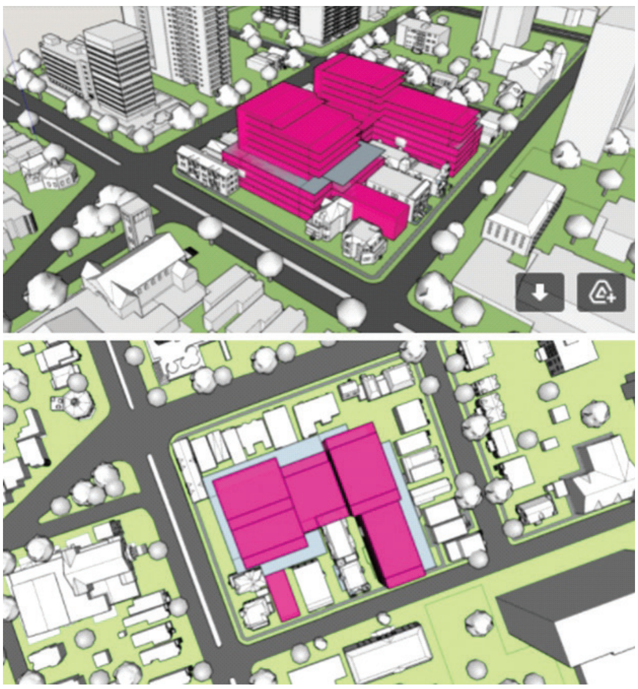

Figure 14: Proposed in-fill design by citizens' group Development Options Halifax (DOH)

The preliminary embodied carbon calculation for the citizens' alternative design is shown in Table 6. According to the table, the alternative design's total embodied carbon impact can be around 18,000 tonnes of CO2e. That means by maintaining the existing buildings, where possible, and building mid-rise instead of high-rise, the embodied carbon of the block redevelopment can reduce by more than 40% (13,000 tonnes of CO2e). This amount of carbon emissions is equivalent to about 17 years of operational carbon from the existing buildings!

Activity	Estimated Construction (m^2)	Embodied Carbon Intensity* (kg CO_2e/m^2)	Embodied Carbon (t CO_2e)
Total New Mid-Rise Construction	~51,000	~270 - 380	~14,000 – 19,500
Renovation of Existing	~8,000	~120	~960
Demolition of Existing	~4,500	~15	~70

Table 6: Preliminary embodied carbon emissions of Halifax Carlton block proposed citizens' design (Mantle)

The net result for area for the DOH proposal is approximately 51,000m2. While the alternative is not drawn as a finished design, its purpose is to illustrate that assuming eleven percent of that space is for circulation, there is enough space for an in-fill that could roughly accommodate 550 to 570 units (60m2 each). That number, in addition to the 75-80 units that will no longer be demolished, gives a total of between 625 to 645 units. Considering it as a mixed-use residential, by changing the two bottom floors of the massing into commercial space, would still allow ~390 residential units (for a total of ~465 units) while offering 1300m2 of commercial space.

The model proposes two floors of underground parking with approximately 365 stalls. Decisions to instead fund car share, bike share, public transit passes rather than invest in parking are options that a progressive society might support instead.

Because of its smaller scale, the estimated embodied carbon emissions for the DOH design can be further reduced by careful choice of fewer and low- to no-carbon materials. And of course, as discussed other in-fill styles could also be imagined.

This case study demonstrates that demolishing buildings before they have reached the end of their useful life has a massive climate and environmental cost. If a city such as Halifax were to optimize the use of its existing buildings by repurposing, renovation, restoring and augmenting with real net-zero carbon in-fill and backyard suites, it could reduce the need for new high rises and demolition, as well as GHG emissions. Worldwide, enhancing existing building utilisation could potentially cut GHG emissions by 11% between 2017 and 2050.[96]

Although the reuse of buildings may seem small in the case of a single building, when the carbon emissions are scaled across a city-wide building stock the impact is huge—remember HRM's 2,535 demolition permits? Imagine the floor area of seventeen city blocks destroyed! We absolutely need to start considering the potential of existing buildings ahead of thinking about demolition and replacement. And we need to get the scale of development right-sized to be carbon negative, carbon positive or real net-zero carbon that includes embodied carbon.

Activity	Invisible Embodied Carbon GHG Emissions (t CO2e)	Weight in Plastic Bags Equivalent	Estimated Number of units.
Developers' towers-construction, demolition, relocation.	~31,000	~5.2 billion	
Citizens' in-fill option, renovation, demolition.	~18,000	~2.97 billion	~550 – 570
Replace demolished buildings-the climate/social cost.	~2,214	~365 million	~109

Table 7: Summary of preliminary embodied carbon emissions of Carlton block developments,citizens' in-fill alternative, demolition's climate/social cost.

The Path Forward, Planning for a Circular Economy

New directions must include a life cycle assessment to quantify both the upfront carbon emissions and the operational carbon emissions during the life stages of a building. By identifying the potential impact of various options, the best choices for reducing the carbon emissions can be made at the design stage of a development. Governments, institutions, policymakers, businesses, professionals, tradespeople, investors, manufacturers, civil society and residents must all act to reduce demolitions, and building and construction-related emissions.

Planning for a circular economy goes even further by replacing the linear economy model—which "progresses" from resource extraction, production and use to its "end-of-life" waste concept—with restoration and regeneration. This is achieved, with a broader aim than reducing GHG emissions, by shifting towards renewable energy, eliminating toxic chemicals and aiming for the elimination of waste through the design of materials, products and systems that are able to be maintained, repaired, reused, remanufactured, dismantled, recycled, leased or shared.

In Nova Scotia a circular economy is a focus area of the goals and initiatives established under the provincially legislated Sustainable Development Goals Act. It is defined as

> *"an economy in which resources and products are kept in use for as long as possible, with the maximum value being extracted while they are in use and from which, at the end of their service life, other materials and products of value are recovered or regenerated.[97]"*

Social, cultural, and economic opportunities are squandered when buildings are seen as disposable and building materials as one-time products that have no function once a building is demolished. These go beyond the fact that communities are tax burdened by the 25-30% of Nova Scotia's waste stream to landfills that flows from the demolition and construction industry. Although this report has focussed on the environmental and climate cost associated with demolition, construction and building, there is empirical evidence that neighbourhoods with a mix of older, smaller buildings of diverse ages support greater levels of positive economic and social activity than areas with large, new buildings.

Older, smaller, mixed-use neighbourhoods, when compared to areas with predominantly larger, newer buildings, are more walkable with a higher transit score; have greater nightlife; are home to and desired by a younger median age and with more age diversity; have greater affordability and flexible space; with a higher proportion of new businesses, women-owned businesses and minority-owned businesses; have greater concentrations of creative economy; and contain a significantly higher proportion of jobs in small businesses[98]. Added to these advantages in the context of a small city such as Halifax is the draw of being a unique historic area that still offers a sense of place. Unfortunately, this is all under threat as developers, condoned by decision-makers, rapidly convert the area to the uninteresting, homogenous, placeless urban typology emerging throughout the world.

Image 10: An in-fill option: 1864 single family house doubles in size to become 10 units. (Photo: P. Cameron)

Greater population density is also found in older commercial and mixed-use districts with more businesses per commercial square foot than in streets with large, new buildings[99]. When demolitions occur, higher unit costs and increased local property tax displace lower income earners. Since 2008, the commodification of real property has been the largest driver behind the global construction boom and higher costs, as the wealthy park their money in urban real estate. Such speculation inflates local land values and is detached from local incomes, such that the working class and poor can no longer afford to live in many of the world's major cities.

Who is densification for if housing units are unaffordable or treated as investment properties?[99] It's estimated that one-half of the condos in Vancouver and one-third of the condos in Toronto are empty, either investment properties or part-time second homes[100]. This investment driver behind construction and building comes at a social, economic, environmental and climate cost. Unchecked market forces, with private sector property developers or wealth management funds as both providers and as primary beneficiaries of housing, are a disruptor rather than a solution for meeting citizens' needs.

In Halifax, affordability and the general shortage of units for families with children is making HRM a city of commuters, since job opportunities continue to be largely on the Peninsula. Ironically, as social stratification within a city is reinforced by displacement of middle- and low-income earners, densification increasingly caters to a wealthier sector with high-impact behaviours or lifestyles.

Transforming Demolition, Building and Construction

In summary, this report has identified ways in which demolition, building and construction in Canada are adversely affecting our ability to reduce our GHG emissions and retain the social, cultural, economic and environmental advantages of smaller, older, neighbourhoods. The Halifax-based case-study shows that the construction of two adjacent proposed high-rise developments will emit 31,000 tonnes of CO2e. Together the projects will require the demolition of 12 to 14 historic buildings. These contain approximately 110 residential and commercial units with a total area of 10,300m2. This is equal to destroying three four-storey buildings of 3,135 m2 or a single mid-rise 12-storey building. The embodied carbon cost of replacing this area will be an unnecessary 2,214 tonnes of global warming emissions.

A smaller-scale in-fill building proposed by the citizens' group DOH would retain all but one of the existing buildings. In addition to the remaining 80 units, this option would add approximately 550 to 570 new units for a total of between 625 to 645. At 51,000m^2 the DOH proposal has a total embodied carbon impact around 18,000 tonnes of CO_2e, a 40% lower embodied carbon cost. This would forego an unnecessary expenditure of embodied carbon to replace existing, useable building area.

With careful planning and design this mid-rise can achieve further advantages. Using low- to no-carbon construction materials and highest green building standards it could be zero-carbon and energy self-sufficient. Its distinct social, cultural, economic and environmental advantages can address the climate crisis and benefit society. Mid-rise projects have lower capital cost, faster project turnaround, reduced operational cost, better community acceptance, retain small-scale, mixed-used character and reduce displacement.

In conclusion, we have no time to waste on regulating the reduction of demolition and requiring carbon budgets for the buildings and construction industry.

Some Recommendations:

“The most aspirational designer can be limited by a client with a narrow strategic vision, and the most aspirational client can be limited by design teams unskilled in delivering net zero carbon. Regulation and policy must be implemented quickly so that the minimum standards are set to deliver net zero carbon.[101]”

Policy

Immediately-

Policy Recommendation 1: Recognizing the carbon cost of demolitions, the material waste and the unnecessary penalty to the climate, society and the economy, Halifax, along with all levels of government—municipal, provincial and federal—must immediately prioritize conserving and adapting buildings as a first course of action, and if demolition is an appropriate last resort, re-using materials more effectively.

Policy Recommendation 2: Recognizing the carbon cost of large-scale buildings, Halifax and all levels of government must change the rules of development to reduce the impact of the industry by requiring a carbon budget for each development. This must include benchmarks for what is permissible now, with targets and timelines for what will be permitted in subsequent years, so there is a 50% reduction in embodied carbon by 2030.

Policy Recommendation 3: Recognizing the limits of growth and the impact of climate change, waste and over-consumption on Earth along with its incumbent inequity, all levels of government must change the policies and practices that perpetuate growth in material consumption and production in order to balance social, environmental and economic measures and create a more equitable human existence. In Nova Scotia this is a focus area of the goals and initiatives established under the Sustainable Development Goals Act that must not continue to be ignored.

Policy Guidance

• Introduce a provincial moratorium on demolitions.

• Create a conceptual path forward to regulate embodied and operational carbon emissions in the building and construction industry using a Life Cycle Assessment (LCA) methodology. Include legally-binding targets, year-by-year timelines, policies and accountability measures with audits to achieve net-zero embodied and operational carbon GHG emissions.

• Develop a framework for an environmental full-cost accounting assessment of the demolition, construction, building sector such as GPI Atlantic, to include environmental, social and economic measures.

• Maximize collaboration to ensure that all involved parties are consulted, but that decisions are independent from industry or government, and the focus and outcome remains on GHG emissions reductions, not on what is politically palatable. This is transforming a culture.

• Develop and enforce scientifically-based, consistent standards on what actually constitutes net zero.

• Adopt zoning practices, including height restrictions that encourage land use patterns that control/reduce/eliminate demolition and increase distributed density.

• Promote less carbon/resource intensive, secondary or recycled materials (reduce/avoid aluminum, cement, petrochemical-based materials and steel).

• Set building codes, planning and specification requirements, rules, regulations, taxes, etc. to create incentives for reducing carbon intensity, with sectoral targets for building and construction that include interim two-year targets enroute to final goal of 50% GHG reduction by 2030—treat carbon like we did cancer-causing cigarettes.

• Set requirements for product labelling for building and construction materials.

• Set requirements for the building and construction industry to measure, report and reduce embodied carbon emissions beginning 2022 for building permitting—this is needed to identify opportunities for reducing GHG emissions in the initial phase, develop capacity and assist future policy development and standardization.

• Set strict absolute limits on embodied carbon emissions for all developments by 2024.

• Set real, legally-binding government targets for net-zero GHG emissions reduction in building and construction sector by 2030, with annual reporting and audits on progress.

• Create material recovery standards for all building demolitions.

• Adopt policies requiring commercial and multifamily building owners to publicly report energy-consumption data.

Building Codes and Permitting

• Make stringent life cycle assessment mandatory prior to issuing building or demolition permits with the intent to disincentivize demolitions.

• Design building codes to transform the building sector, not for minimum standards, that is to mitigate emissions, increase resiliency and durability.

• Require carbon budgets for all renovation or new construction permits at the application stage that includes embodied carbon and operational carbon accounting and targets whole life net-zero carbon.

• Set carbon caps for building archetypes that incentivize decarbonization through performance ratings.
• Require material and product resources for renovation or new construction to measure and declare carbon emissions.
• Set low-carbon compliance requirements for materials.
• Pioneer new energy code based on flexibility and measurement for existing buildings, i.e. incorporate flexibility so deep retrofit requirements can be tailored to building type.
• Evaluate building energy performance certification programmes from the perspective of carbon lock-in potential.
• Harmonize building code requirements with GHG emissions reduction objectives (reduced parkade requirements, low-carbon materials use, accommodation for renovation or adaptive re-use).

Trades
• Demolitions to be conducted by licensed tradespersons so that dismantlement maximizes materials reuse.
• Best practice targets for embodied carbon stipulate that the building is made from re-used materials and can be disassembled at end of life for re-use, re-cycling or re-purposing.
• Standardize technical data (e.g. on construction materials, window retrofit vs. replacement, testing & certification, etc.)
• Standardize, support and invest in skills and educational training of industry players in netzero carbon, high performance building design and construction (e.g. architects, designers, project managers, engineers, tradespeople, construction workers, building inspectors, academic and trade school instructors) with requirements for regular training session updates.

Incentives
• Set a penalty schedule for demolition based on the total area to be demolished.
• Set costs higher for carbon intensive developments (e.g. development cost surcharges, property tax) and incentivize low- or no- or carbon draw-down projects with low environmental impact (e.g. reduced development cost surcharges, Development Permit Area guidelines, expedited approvals, tax exemption bylaws, fee rebates, innovative financing, building labelling, etc.).
• Work with investment institutions, real estate agents and public to identify risks associated with carbon-intensive developments and make climate change a key priority in financial decision-making to get to a net-zero carbon economy.
• Create financial incentives for carbon neutral or carbon draw-down building retrofits and additions that prioritize those citizens with the greatest need.
• Set a target to upgrade at least 5% of the building stock to zero- or near-zero emissions structures each year.
• Develop comprehensive building-by-building performance data to support tracking and recording a building’s energy performance over time, and identify opportunities for operational efficiency improvements and retrofit projects, and to inform policies, programmes, incentives and investment.

Conclusion— Limits to Growth Turns Fifty

We're fast approaching the 50th anniversary of the 1972 publication of Limits to Growth [102] where a team of MIT scientific researchers and modelers warned of the outcome of unfettered human demand on Earth's resources. The treatise triggered discussion and criticism even though it offered hope by acknowledging that human ability to curb consumption and production is effectively a choice, and that a balance between ecological and economic stability can be achieved and result in a more satisfying human existence.

In a re-visit to The Limits to Growth: the 30 Year Global Update[103] the warning was starker and climate change and other resource uses and pollutants acknowledged as stretching past Earth's capacity. But again, it offered hope for reducing this trend by changing policies and practices that perpetuate growth in material consumption and in population; by more efficient use of materials and energy; and, by balancing sufficiency, equity, and quality of life rather than quantity of output.[104] It outlined choices that could be opportunities.

Now let the creativity and metamorphosis begin.

Glossary

carbon budget — defined according to what is being assessed (i.e. global, national, municipal, individual, infrastructure, project or building), this is the total amount of GHG emissions that may be permitted to be released. In the case of the building sector as an example, this could target a 50% reduction in GHG emissions by 2030 from a 1990 baseline, with further reductions thereafter having an objective to have both embodied and operational carbon become neutral, or remove CO2 from the atmosphere.

carbon intensive building materials — materials and products that release high GHG emissions during production. The kind of energy used (coal-fired or gas-fired vs. renewable) may be a factor, but the intensity may also be associated with chemical composition and processes, extraction or waste by-products.

carbon negative or carbon positive — confusingly these terms may be used interchangeably for a circumstance where a process or product removes carbon dioxide (CO2) from the atmosphere—effectively carbon capture and storage. **Carbon positive** may be considered to go beyond **carbon negative** by storing and producing more energy on site than the building requires and feeding it into the grid.

circular economy or cradle to cradle — a regenerative economic model where resources, products and materials are cycled through their highest use, reuse, renewal, refurbishment or recycle. This is similar to many cycles found in nature's ecosystems.

embodied carbon — Greenhouse gas (GHG) emissions—the majority being **upfront carbon emissions**—generated by construction material manufacturing and processes, transportation and end-of-life disposal or recycling (11% of global emissions).

energy self-sufficiency — for a building, one that offsets its operational energy use by what it generates, via solar panels, for example.

environmental full-cost accounting — an accounting practice that identifies all the costs of a good or service, not just financial, relating to a product, including hidden environmental, social and economic costs. These can include climate change, resource depletion, loss of biodiversity, air/water pollution, well-being etc. **Genuine Progress Index Atlantic (GPI Atlantic)** is an example of environmental full-cost accounting; a "triple bottom line" practice that includes measures of environmental, social and economic well-being.

linear economy or cradle to grave — a degenerative economic model where “resources” are extracted, manufactured into products, sold, used and eventually thrown away and where air or water pollution, GHG emissions, by-products and resource depletion are regarded as external or free services of nature.

low-rise, mid-rise, high-rise — For this report embodied energy intensity is presented for low-rise (1-6 storeys), mid/high-rise (7-15 storeys), high-rise (16-25 storeys), and high-rise (25+ storeys). The Canada Green Building Council defines a low-rise MURB as a four-storey building of 3,135 m2; a mid-rise as a ten-storey building of 7,830 m2. (Confusingly) these terms are not standard.

net-zero carbon or carbon neutral — confusingly these terms are used interchangeably but have different approaches to reducing GHG emissions. **Carbon neutral** buildings achieve neutrality by buying carbon credits or by financially supporting renewable-energy projects (on-site or elsewhere) to offset emissions from the energy the building uses (operational energy). This energy self-sufficiency does not necessarily seem to account for embodied carbon. For example, an energy-efficient building may consume very little operational energy but it may contribute a large amount of GHG emissions by using carbon-intensive materials for its construction or renovation (embodied carbon). **Net-zero carbon** buildings reduce GHG emissions to the extent possible and invest in ways to remove CO2 emissions it does produce. Unfortunately, this generally does not account for embodied carbon. It needs to.

net-zero embodied carbon — a building or asset where GHG emissions from materials and products are zero or are offset, that is to say compensated with energy production elsewhere, or the removal of CO2. This can be achieved with careful design, building placement or orientation, material selection and reduction of new materials or waste.

net-zero upfront carbon — a building where the total GHG emissions from material manufacturing and processes, transportation and construction are zero or, through the use of offsets, equal to zero.

operational carbon — GHG emissions associated with heating, cooling, and lighting an asset/building (28% of global emissions).

upfront carbon — GHG emissions associated with materials and production and construction processes up to the completion of an asset (including resource extraction, transportation, manufacturing, construction).

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Table 4. Life-cycle analysis comparing embodied energy and operating energy between reuse of an existing building and construction of a new building, illustrating the time it takes before a net energy savings is achieved

These three scenarios all point to the fact that reusing an existing building and making it more energy efficient results in an immediate savings of total energy use. If building new, no net savings of total energy are achieved until a future date that can be greater than the life expectancy of many new buildings.

Scenario 1: Do nothing to the existing building and build a new building. The existing building will remain and be used by a different user. The new building will be designed to meet Energy Star standards of operating efficiency.

- Embodied energy 1,200 MBtu/sq. ft. for the new building (mid-range value)
- Existing building operating energy at 70,000 Btu/sq. ft.
- New building operating energy at 35,000 Btu/sq. ft.

34.2 years before any life-cycle energy savings is achieved

Scenario 2: Demolish the existing building with partial salvage. Construct new office building to meet Energy Star standards.

- Embodied energy: 1,200 MBtu/sq. ft. (existing)
- Embodied energy: 1,200 MBtu/sq. ft. (new)
- Embodied energy: - 400 MBtu/sq. ft. (salvage)
- Total embodied energy: 2,000 MBtu/sq. ft.
- New-building operating energy at 35,000 Btu/sq. ft.

57 years before any life-cycle energy savings is achieved

Scenario 3: Renovate existing building, improving its efficiency by 30 percent, although not meeting Energy Star performance standards. Construct new building to meet Energy Star Standards.

- Embodied energy: 400 MBtu (rehab)
- Operating energy: 50,000 Btu (rehab)
- Embodied energy: 1,200 MBtu/sq. ft. (new)
- Operating energy: 35,000 Btu/sq. ft. (new)

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Key Findings ESTCP SI 0931

1. Modernization of DoD's masonry Pre-War Buildings can be **significantly less expensive** than new construction.
2. DoD's LEED Silver standard can be met at **less cost with modernization** and Pre-War Buildings can contribute significantly to DoD's goals of lowering GHG emissions.
3. By leveraging original design features for thermal comfort ("original design intelligence") with new, energy-efficient buildings systems, DoD can modernize Pre-War Buildings to **match the energy performance of new construction**.
4. **Mission critical facility requirements can be fulfilled** through the adaptive reuse and modernization of Pre-War Buildings.
5. Historic buildings should be considered a **valuable asset** and their reuse and modernization should be integrated into installation master plans.
6. Prescriptive and rigid application of AT/FP and progressive collapse standards can result in significantly **higher modernization costs and at the same time generate higher levels of Scope 3 GHG emissions** than carefully specified AT/FP treatments.

Recommended Actions

1. Military planners should explore modernization and repurposing of Pre-War Buildings **before** considering new construction to meet installation mission requirements.
2. Military service procurement procedures should be reviewed and revised to ensure **selection and use** of contractors with experience and knowledge of historic structures.
3. DoD's MILCON and SRM funding programs should be reviewed and revised to **avoid piece-meal improvements** to historic structures and instead provide for full modernization.
4. DoD should work with GHG emission tool developers to formulate an **integrated GHG calculator tool** that covers Scope 1, 2, & 3 emissions and is compatible with commercial cost estimation systems.
5. DoD should consider **reporting GHG metrics** on DoD Form 1391 as part of the MILCON funding decision-making process.
6. Prescriptive and rigid application of AT/FP and progressive collapse standards should be avoided. Greater emphasis on installation-wide security measures can **lower** AT/FP compliance costs for historic, and other existing structures.

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https://woodknowledge.wales/wpcontent/uploads/2020/12/WKW_tech_doc_final_2.12.2020.pdf

55. 'United Nations and Headquarters.' (2015). Athena Sustainable Materials Institute. http://www.athenasmi.org/resources/case-studies/united-nations-headquarters/. A life cycle analysis of the New York United Nations Headquarters and Campus found that rehabilitation instead of new construction prevented the emissions of 50,000 metric tonnes of CO2. Also, that a replacement building with better energy performance would take 35 to 70 years to pay back its embodied GHG debt from emissions associated with the demolition and new construction process. For details and other examples are available on the Athena website

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Table 12. Number of Years Required for New Buildings to Overcome Climate Change Impacts from Construction Process

According to this study, it takes 10 to 80 years for a new building that is 30 percent more efficient than an average-performing existing building to overcome, through efficient operations, the negative climate change impacts related to construction. This table illustrates the number of years required for different energy efficient, new buildings to overcome impacts.

Building Type	Chicago	Portland
Urban Village Mixed Use	42 years	80 years
Single-Family Residential	38 years	50 years
Commercial Office	25 years	42 years
Warehouse-to-Office Conversion	12 years	19 years
Multifamily Residential	16 years	20 years
Elementary School	10 years	16 years
Warehouse-to-Residential Conversion*	Never	Never

*The warehouse-to-multifamily conversion (which operates at an average level of efficiency) does not offer a climate change impact savings compared to new construction that is 30 percent more efficient. These results are driven by the amount and type of materials used in this particular building conversion. The warehouse-to-residential conversion does offer a climate change advantage when the energy performance levels of new and existing building are assumed to be equal (see Figure 14). Thus, it may be particularly important to retrofit warehouse buildings for improved energy performance while renovating them. Furthermore, care should be taken to select materials that maximize environmental savings.

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Biogenic Carbon Calculator: https://www.worldwildlife.org/projects/biogenic-carbon-footprint-calculator-for-harvested-wood-products;
Building Transparency's Embodied Carbon in Construction Calculator (Ec3), https://www.buildingtransparency.org/en/;
OpenLCA- open source Life Cycle Assessment, https://www.openlca.org-;
Open technologies, https://opentech.eco;
2030 Materials Palette, https://materialspalette.org/;
PHRibbon, https://www.phribbon.co.uk; PHPP v9.6, https://www.passivehousecanada.com/shop/software/phpp/;

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