We Need Regulations to Reduce Upfront Carbon Emissions in Buildings

Building a Sustainable Future

Building rests on a concrete ground floor

Prefab heavy timber construction

Promotes natural light and ventilation.

Heating and cooling are via radiant ceilings.

Rainwater is harvested and filtered for non-potable uses

Ground source heat pump.

Construction time 1 year – 17 weeks on site

Cut upfront carbon by 32%

1925 Victoria Park – Toronto's first sustainable Toronto Green Standard apartment building

Photo courtesy of Lloyd Alter Lloydalter@me.com

Despite Canada's lofty emission targets of 40 to 45 per cent below the 2005 level by 2030, emissions in Canada continue to rise. Although the burning of fossil fuels is the largest emitter of GHG (Green House Gas) emissions, it's increasingly important to look for all possible ways to decrease emissions.

Construction is the single largest source of material usage on the planet. Together, building materials, construction, and building operations account for 40 percent of total global annual CO2 emissions. Of that, a third is attributable to upfront carbon. Canada is embarking on a housing construction boom. It's an opportune time to look at how we can reduce emissions in this sector.

In Canada the building sector is the third largest GHG emitter. It comprises two categories:

1. **Upfront carbon emissions (also called embodied carbon emissions)** are the portion of GHGs resulting from materials and construction processes up to completion of an asset.
    - cradle to grave upfront emissions include resource extraction, transportation, refining and manufacturing before delivery, delivery to customer, construction, installation, and construction waste and once built, maintenance, renovation, demolition, and disposal.
    - Upfront carbon emissions in the building sector account for 11% of global greenhouse gas emissions.
2. **Operational emissions** result from heating, cooling, lighting, and powering the mechanics and systems in the building.

The upfront carbon emissions vary with the type of building materials.

The most carbon intensive materials are concrete, steel, aluminum, and insulation. World-wide, concrete is the biggest source of upfront carbon - 8%. Cement makes up only 10 percent of the concrete mix, but it is responsible for over 80 to 90 percent of concrete's upfront carbon because it's production involves heating a mixture of limestone, silica, alumina, and gypsum to 1,400-2,000 degrees Celsius. The heat-intensive process often uses fossil fuels, but also, the chemical reaction itself generates CO2. Limestone, fly ash or slag, can be substituted or partly substituted for cement to reduce carbon emissions. Fly ash is a byproduct of coal fired power plants. As coal plants are phased out it will be less available. The best option is to use less concrete.

Steel is also high in embodied carbon. The amount of embodied carbon depends on:

- The source of energy used in production - coking coal, fossil gas, or electric arc.
- The electric arc process is less carbon-intensive, but a lot depends on the electricity grid. If electricity is generated by gas fired plants, it still produces substantial GHGs.
- The amount of recycled steel used.

- If it is locally sourced and if imported, country of origin.

Aluminum is the most carbon intensive of all building materials. Primary aluminum production is energy-intensive, using about ten times as much electricity as steel. As such, the key factor that impacts the embodied carbon of aluminum is the carbon intensity of the electricity used. Aluminum produced in Canada is comparatively low in carbon emissions because it is produced in Quebec with hydro power.

Aluminum is used for framing of high-rise windows, window walls and window curtain walls. Its life cycle is limited and then it needs to be replaced.

Embodied carbon varies with the type of building.

High-rises are by far the most carbon intensive for both embodied and operational emissions because they require a lot of concrete and steel for stability. The taller the building the more concrete and the more steel.

Kelly Alvarez Doran, architect and U of T associate professor calls high rises carbon icebergs because most of the upfront carbon is underground. Mid-rise and tall buildings across Toronto have exceptionally large concrete basements.

- The taller the building, the deeper the concrete foundations.
- The more underground parking, the more concrete.
- Concrete is used for the parking garage floors and a very thick transfer beam to then needed between the parking garage and the floors.
- As a result, between 30 and 60 % of mid-rise and tall buildings' upfront emissions will be below ground. It is concrete-intensive to dig a hole, shore it, and retain it.

Mega-tall buildings require massive amounts of concrete and steel to stabilize the upper storeys because wind loads increase with height. Any sway at all introduces enormous destabilizing forces into the structure below. There is often as much concrete in the foundations as there is above ground.

Typically, tall buildings are clad with window walls and curtain walls which have the highest carbon intensity of all building cladding because the framing is aluminum.

Aluminum-extrusion-glazes and façade systems carry the highest embodied GWP (global warming potential) by volume of all building materials.

Tall buildings require more energy to operate because window walls are difficult to heat and cool. Mechanical services that raise water, coolant, people and air to great heights are energy intensive. A study by the UCL Energy Institute found a direct relationship between energy consumption and height. There are health issues as well. An IPCC (Intergovernmental Panel on Climate Change) report found that the urban heat-island effect is driven by tall buildings that create urban canyons, blocking winds from cooling things down and locking in heat. And we know heat kills.

Toronto has the third highest number of skyscrapers in North America. There are more than 100 high-rise buildings currently under construction and a further 300+ that are proposed or approved. Of these, 8 are super-tall skyscrapers ranging from 58 to 91 floors. This is housing for the wealthy and super-rich. Units in Sky Tower range from $1.2 million to more than $3 million for units of 780 to 1,650 square feet. At The One, units are priced from $3 million to $31 million.

The Carbon Cost of Demolition

"The greenest building is…one that is already built" — Carl Elefante, 2007

Demolition has become the standard practice in housing developments, save for the occasional heritage building. Demolition releases a lot of GHGs and other pollutants into the air and soil. Retrofitting and upgrading buildings is far more energy and carbon efficient than demolishing it and building a new energy efficient building of a similar size. Demolition requires energy to tear down, remove, process, and dispose of the waste. GHG's may also be released through associated chemical processes. Building a replacement requires more materials and energy, creating more upfront carbon. If a building must be torn down, reusing or recycling building materials can reduce the upfront carbon of demolition.

A study in Halifax of a proposed development, compared carbon emissions for the proposed demolition of more than a dozen low rises and replacement with four high-rise towers, to the carbon emissions if most buildings were renovated, and one new nine story building was added. The study found that the retrofit and 9 story in-fill project would emit 40 per cent less carbon than the proposed new 4 towers, while still increasing density.

Architecture 2030, a non-profit, has developed a digital tool, CARE (Carbon Avoided Retrofit Estimator) used for estimating and comparing the embodied, operating, and avoided carbon impacts and benefits of reusing and upgrading existing buildings or replacing them with new construction.

The Density Conundrum

Toronto is a city of neighborhoods of single-family homes and neighborhoods of high rises. With not much in between.

There is growing research that challenges the belief that building taller means greater density because tall buildings make optimal use of space, reduce operational energy use and energy for transportation. A study by Francesco Pomponi, which decoupled density from tallness concluded that “there is no merit to the claim that building denser and taller is more sustainable. By building dense, low-rise urban environments, the same populations can be accommodated for drastically lower carbon costs and without having to significantly increase land use”.

Essentially, more people require more space, but high-rise buildings require a similar land area compared to low-rise buildings with varying density. This is due to the space required when building taller; buildings must be further apart for structural reasons, urban policies, and occupant comfort. Therefore, building taller to accommodate a growing population does not always save space, but also significantly increases LCGE’s (Life Cycle GHG Emissions). High rises also require a significant amount of space for elevator banks and operational mechanics. The exception is mega tall buildings. However, units in mega-tall buildings are only affordable for the ultra-rich.

In *In Praise of the Dumb Box*, Lloyd Alter explains the virtues of buildings that are less than 6 stories, and can manage without power for long periods, unlike tall buildings that become a risk for residents in power outages. Not a bad strategy for adaptation to ever increasing climate events. A neighborhood of dense, dumb boxes is the most resilient, cheaper to build, the least carbon intensive and has lower operational costs. Low-rise buildings can be built without basements and can be built with less carbon-dense materials. If they are below 6 stories they don't need elevators. Montreal, Barcelona, and Paris are full of dense, low-rise buildings.

Dumb box architectural designs can easily adapt to different sized lots and an architect isn't necessary for every building. This is in keeping with the federal government's plan to issue a standardized housing design catalogue expedite building. It's suitable for modular construction which is less disruptive for the community and for traffic.
Some examples of dumb boxes are:

A small apartment building in Paris – wood construction, a single stair and no elevator.

Photo courtesy of Lloyd Alter Lloydalter@me.com

Vienna.

Photo courtesy of Lloyd Alter Lloydalter@me.com

Vienna. Wooden apartments built above stores.

Photo courtesy of Lloyd Alter Lloydalter@me.com

321 Dovercourt Rd. Toronto, Modular Supportive Housing providing 44 studio apartments for people exiting homelessness

Photo: Gail Fairley

Toronto's Official Plan Chapter 2 lays out planning in 3 types of neighborhoods.

- Development in low-rise, low-density residential areas will maintain the physical character of buildings, streetscapes, and open space.
- Development in residential areas with taller buildings and higher density will be consistent with this objective. On sites containing one or more existing apartment building(s), and sufficient space compatible infill development may take place.
- Developments in mixed use areas, regeneration areas and apartment neighborhoods that are adjacent or close to low-rise neighborhoods will provide a gradual transition of scale and density.

Clearly Toronto plans to protect single family home communities, while allowing developers to continue to erect what Lloyd Alter calls "carbon bombs" – high rises and skyscrapers. Perhaps we need a moratorium on them.

We need a carbon budget for buildings.

Toronto is developing a carbon budget for emissions. This is to be celebrated. But it does not include upfront carbon. Perhaps we need a carbon budget for individual buildings and developments that includes upfront carbon. *Buildings For the Climate Crisis - A Halifax Case Study,* recommended governments 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. It recommended including 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 upfront carbon emissions by 2030. Architect Kelly Alvarez Doran is an advocate for upfront carbon budgets and benchmarks. Vancouver is leading the way and is the first place in the world to establish upfront carbon policies for all new Buildings. Vancouver will support the policies by promoting the use of lower-carbon materials in new construction, supporting the education of trades on using lower-carbon materials in construction, and aligning low-carbon policy with their planning regulations.

It's an opportunity Toronto and other cities should embrace.