Future-Ready Design Guide

for multi-unit residential buildings

between 4 *and* 18 storeys

for architects working in the Greater Golden Horseshoe

Toronto Society of Architects
v1.0.0

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Foreword

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It has been said that history doesn't repeat itself, but it often rhymes.

In the 1940s, Toronto was in a deep housing crisis. The Great Depression and World War II had created a severe housing shortage, and the existing housing stock had been left to deteriorate. Low incomes and unemployment made housing ownership unattainable to thousands of Torontonians, and doubling up and overcrowding had become more common as families were pushed to share their dwellings with others to make ends meet. And the problem was about to get worse as veterans returned from the war and immigration levels rose dramatically. Something had to be done.

The response—though much delayed by squabbling between government levels over whose responsibility it was to solve the situation—was nothing short of remarkable. Building fast, affordable and dignified housing became a national priority, with both government and private developers playing a role in creating tens of thousands of new homes, much of them in the form of apartment towers. Between 1952 and 1975, Toronto built 500,000 purpose-built rental apartment units with designs that prioritized efficient layouts, access to light and air, and sufficient space for growing families. Half a century later, these buildings still represent an important part of Toronto's housing stock and a vital source of affordable rental housing in the Greater Toronto Area.

Today, our region is once again facing a severe housing crisis, at an even larger scale and made even more challenging by skyrocketing housing costs that have far outpaced wages. Solving this crisis will require an effort equal or greater to our post-war housing boom, and the apartment building—or Multi-Unit Residential Building (MURB)—will once again be a key protagonist. Much like their predecessors of the 60s and 70s, the sheer number of these new MURBs will inevitably reshape the character of our region, and decisions on their design will affect generations to come. Built right, these MURBs will become valuable assets and cherished buildings of our communities. Done wrong, they run the risk of becoming long-term liabilities that are both undesirable and expensive to upkeep.

The Future-Ready Design Guide for Multi-Unit Residential Buildings, a first-of-its-kind resource put together by the Toronto Society of Architects and made possible through the generous support of The Atmospheric Fund, is our way of contributing to the future success of these MURBs. In these pages, you will find not only best-practices and strategies to make resilient, efficient and comfortable residential buildings, but also vital information on the changing context we must design for to ensure our buildings' longevity—including, of course, our changing climate.

If the MURBs we build today are to be an asset rather than a liability, they will need to not only meet our current pressing social and economic challenges, but be ready for the climate and energy demands of our future.

This last aspect is perhaps the biggest differentiator between our previous housing crisis and our current one. Today we are much more aware of the environmental impact of our built environment, and the difficult reality that our current weather is not the one our buildings will need to withstand in 50 years. If the MURBs we build today are to be an asset rather than a liability, they will need to not only meet our current pressing social and economic challenges, but be ready for the climate and energy demands of our future. Designing for climate action isn't just a nice-to-have, it is a necessity if we care about durability, resilience, long-term affordability and the responsible use of our resources. In a crisis as large and complex as this one, designing to code minimum just won't do.

The information in this guide is nothing new. In fact, many of the resources and best practices you will find in it have been around for quite some time. But what makes this guide different—and what we hope will make it the go-to resource in studios across the region—is that it has been specifically designed for busy practitioners who don't have time to sift through dozens of reports and publications. Just as importantly, this guide is context-specific, addressing the unique challenges of the Greater Toronto region and reminding us of the resources that make the Greater Golden Horseshoe such a special place to design in.

The crisis we face is daunting, but history shows Toronto is up for the task. Equipped with the right information, and supported by the resources developed by decades of researchers, academics, and practitioners, our generation has the unique opportunity to not only significantly reshape the character of our region, but to ensure what we build will be an asset for future Torontonians.

We know you are up for the challenge, and we hope this guide can become your trusted ally in this effort.

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Why a future-ready design guide?

This guide is primarily intended for architects and their consultants, but also aims to provide helpful information for owners, developers and municipalities.

Future-ready housing must be a lasting asset, not a liability. Climate change, affordability, and shifting demographics demand buildings that are low-carbon, adaptable, and cost-effective over their lifespan.

Designing beyond minimums ensures resilience, reduces long-term costs, and preserves essential public resources.

What does future-ready mean?

Buildings outlive those who design and construct them, making it essential that they serve as a long-term asset rather than a future burden. This is especially true for housing, where short-sighted decisions can lead to lasting consequences.

The future is uncertain. Climate change demands both mitigation and adaptation, requiring housing with low embodied carbon and minimal operational emissions. At the same time, rising demand for affordable housing places pressure on budgets—but designing cheaply often leads to higher costs in the long run. Poorly planned housing is expensive to maintain and operate, making it neither economical nor sustainable.

Shifting demographics and an increasingly diverse society call for housing that is adaptable, accessible, and responsive to changing needs. Multi-generational and collective households are becoming more common, and homes must be designed to support aging in place and evolving family structures.

Meanwhile, aging infrastructure and population growth are straining public resources, making it critical to contain urban expansion and reduce the demand on energy and water systems. If we fail to design for the future, essential public funding for healthcare, education, and other social services will be redirected to maintaining failing infrastructure.

Why future-ready design matters

Due to increasingly extreme weather and climate events, insurance premiums and rates are sky-rocketing. Resilient and future-ready buildings can mitigate these rising costs.

This guide focuses on MURBs, addressing not just climate action but the broader challenges shaping the built environment. Future-ready design means considering long-term performance, resilience, and adaptability—not just meeting today's minimum requirements. Our goal is to raise awareness across architecture, engineering, and construction on how to integrate life cycle thinking into housing design—and to ensure this knowledge is accessible to those who can make a difference.

Click here to view advocacy resources that promote the future-ready design of buildings.

Future-ready design is a practical, evidence-based approach rooted in building science, developed to address the urgent need for climate mitigation, climate adaptation, affordable housing, and socioeconomic stewardship.

Future-readiness serves as an ethical foundation, supporting a multitude of positive outcomes across architectural education, practice, and research. When architecture balances resilience and sustainability with beauty and meaning, it fulfils its highest purpose—creating spaces that truly nourish the human spirit.

Future-readiness is about a comprehensive and strategic approach to design

Buildings need to be understood as systems ("building-as-a-system") with integrated, interdependent components that affect performance, cost, occupant health, resilience, and the environment. Conventional design processes have reduced buildings to a series of disparate parts that are arbitrarily designed and bolted-on, one after the other, without particular attention paid to whole-system optimization.

Currently, the largest threat to MURB security, resilience, and life cycle cost is the climate crisis.

Climate crisis and a nation under pressure

Climate change is reshaping our world, bringing environmental degradation, biodiversity loss, and extreme weather events. Communities are being devastated by droughts, wildfires, and flooding, threatening safety and stability.

In Canada, climate challenges are compounded by economic uncertainty, a growing affordable housing crisis, and the strain of aging urban infrastructure. Suburban sprawl drives unsustainable growth, while urban cores crumble under the weight of underfunded municipal resources. We're left questioning whether our current way of life is sustainable without meaningful change.

Architecture's role in climate action—beyond emissions

Buildings are a significant source of carbon emissions through embodied carbon in materials, ongoing operational emissions, and recurring emissions from maintenance and renovations. Climate action design offers architects a way to help mitigate these impacts by influencing how buildings are conceived, built, and maintained.

Climate action design isn't just about reducing greenhouse gases—it's a broadband response to many issues tied to the built environment. Prioritizing sustainable practices can help address housing shortages, urban sprawl, and infrastructure inefficiencies, simultaneously.

For architecture to embrace climate action, the profession must undergo change. Education, training, and practice must all evolve to prioritize sustainable design. Practitioners must become stewards of climate action and competence.

Architects can't make this shift alone and need to work with their clients. Codes, policies, construction technology, and economic systems must align to support sustainable development.

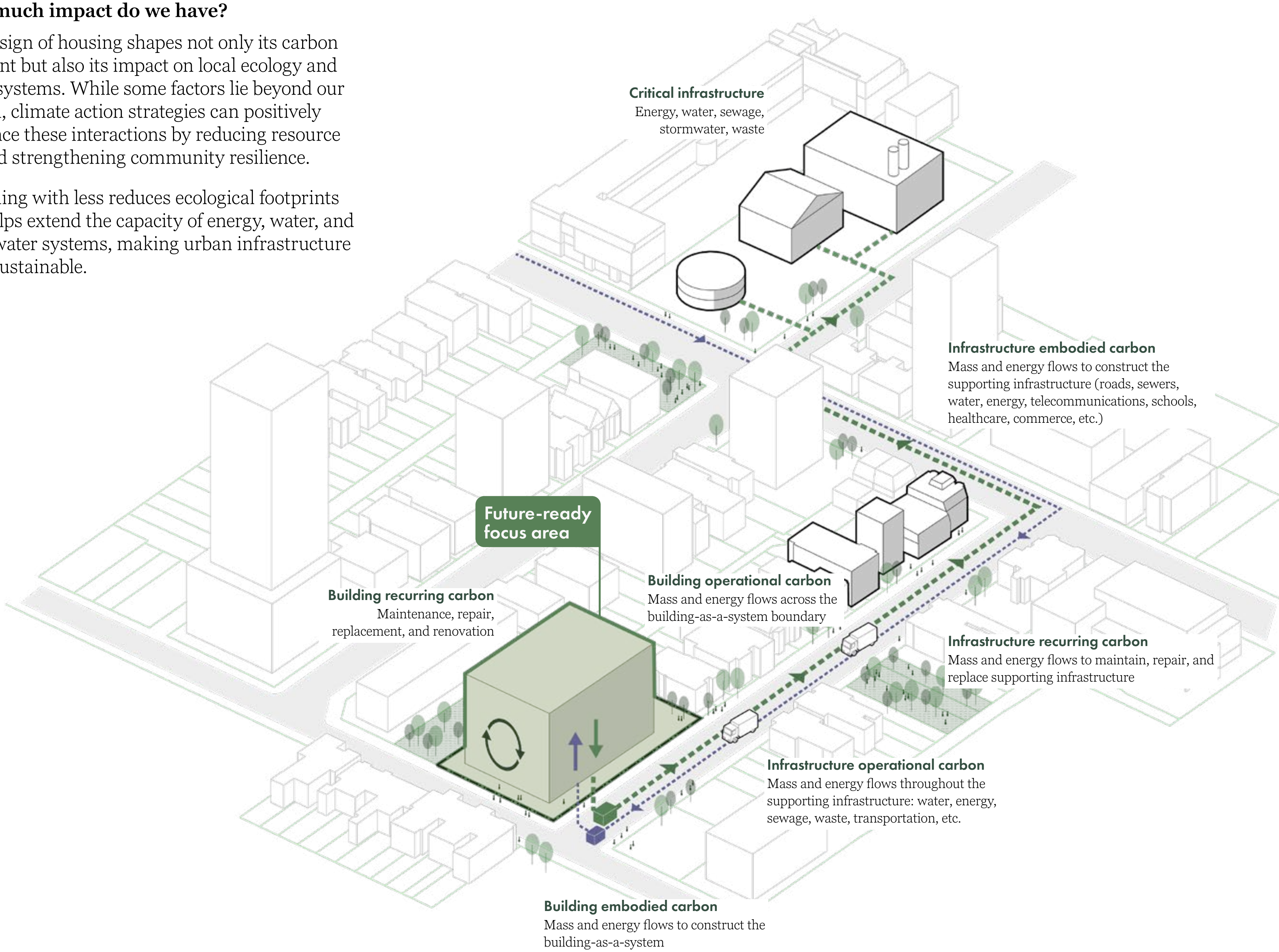
This guide represents a single step in the journey toward creating resilient, sustainable housing in complete communities—a small contribution toward re-imagining architecture for the benefit of both people and the planet.

Intro
Context
Summary
Concepts
Strategies
Appendix

How much impact do we have?

The design of housing shapes not only its carbon footprint but also its impact on local ecology and social systems. While some factors lie beyond our control, climate action strategies can positively influence these interactions by reducing resource use and strengthening community resilience.

Designing with less reduces ecological footprints and helps extend the capacity of energy, water, and stormwater systems, making urban infrastructure more sustainable.



We surveyed the industry and learned what practitioners are looking for

Through surveys with our members, we discovered that the primary barrier to meaningful climate action isn't a lack of knowledge or expertise among architects. Instead, practitioners face challenges in translating climate action strategies into practical, actionable solutions that align with client expectations and regulatory frameworks.

Uncertainty in regulation adds further complexity—we may not be able to depend on governments to enforce higher standards. With shifting priorities, architects are left navigating how to meet climate goals in a way that is both impactful and resilient to policy changes. This guide aims to provide strategies to that end.

Perhaps more than ever, modern practitioners are balancing an increasing number of requirements. Buildings today are more technically complex than they have ever been. Keeping clients, contractors, and users up to speed on best practices is yet another key barrier to adopting higher standards. In plain language and explanatory diagrams, this guide aims to mobilize climate action knowledge into intuitive, straightforward concepts.

Practitioners already have the right skills for climate action

As architects and designers, we are tasked with making highly consequential decisions throughout the design process. Climate action doesn't just mean adding more insulation to our walls or installing solar panels on the roof.

Climate action runs deep and includes processes throughout the value chain. Practitioners are already highly adept at considering and balancing a multiplicity of design requirements. By recognizing this skill, and understanding the impacts of the levers we control throughout design, we can make a significant impact on reducing a building's carbon footprint over a its life cycle without compromising livability or affordability.

Click here to view climate action planning and design resources.

The first resource made specifically for practitioners working in the GGH

This guide is not the first publication to provide information on climate action design. However, existing resources are often technically dense or non-specific to our region.

The goal of this guide is to consolidate best practices from across different subject areas, building a concise, useful guide for architects and designers. This is a tool aimed squarely at practitioners working throughout the Greater Golden Horseshoe (GGH) area, with an emphasis on pragmatic, first-principles approaches to climate action.

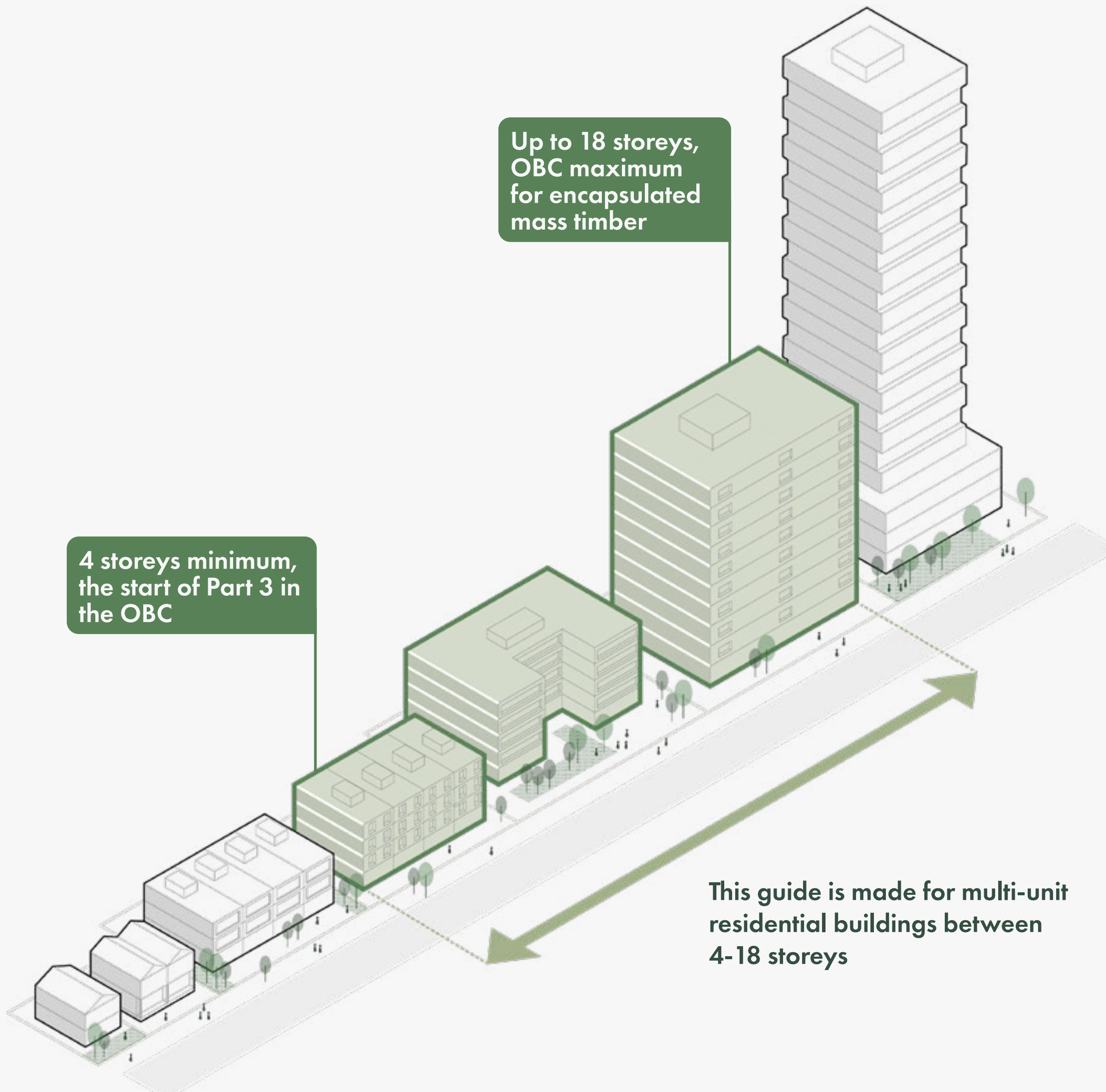
We hope that this guide will help you make design decisions early-on that have major, order-of-magnitude impacts on sustainability metrics across the board, meeting or exceeding existing standards for sustainability.

Scope

Multi-Unit Residential Buildings (MURBs) run the gamut. For the purpose of this guide, we are focused on MURBs that are between 4-18 storeys.

This range was selected to align with criteria set forth in the Ontario Building Code (OBC). Since this guide is largely targeted towards architects, we have started the range at four storeys—the regime in which Part 3 of the OBC begins, and the height we believe is key to achieving the densities required for more sustainable communities.

18 storeys is the maximum allowed for encapsulated mass timber construction in the 2025 version of the OBC.

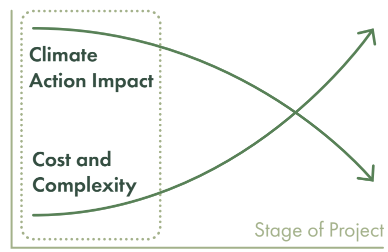


How to navigate this guide

This guide is primarily intended to serve as a design aid used by professionals with a competent background in the design of buildings. It is not intended to be comprehensive, but instead highlights the critical aspects of future-ready MURB design.

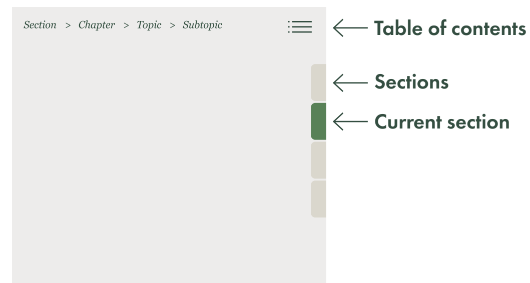
Start using this guide at schematic design or earlier

Earlier is better when it comes to cost, complexity, and impact. This guide focuses on high-level decisions that can be made early-on.



The following elements of this guide are interactive

Click on these useful buttons to navigate the guide quickly, like a website.

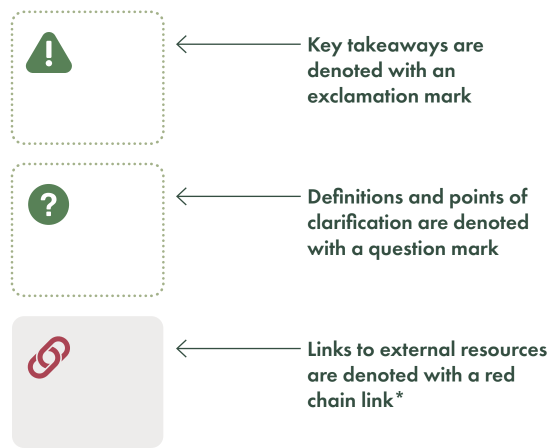


Look for helpful call-outs and links to useful, free resources

While we tried our best to keep the guide concise, there is obviously still a lot of information here.

Keep an eye out for callouts that provide quick, high-level takeaways or definitions; or, click on downloadable link buttons to access additional, curated resources that are available to download.

**If you are viewing this guide in a web browser*, Cmd/Ctrl click on external links to open resources in a new tab.



Understanding our context

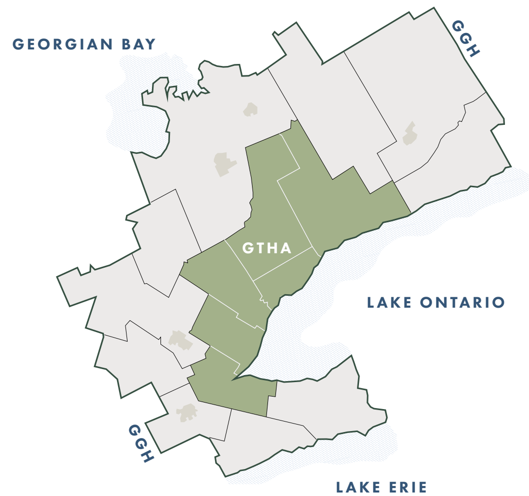
A primer on the Greater Golden Horseshoe

Designing MURBs in the Greater Golden Horseshoe (GGH) region of Ontario demands at least a cursory understanding of the local context.

While many strategies may be applicable to similar North American climates, unique regional factors—such as proximity to the Great Lakes, a unique Ontario electrical supply, and rapid urbanization—necessitate tailored approaches.

This guide outlines key considerations for practitioners working to address future ready multi-unit residential building design in Southern Ontario.

Click here to jump forward to *The Greater Golden Horseshoe in Detail*



What makes the GGH different?

Housing might be the most universal type of building, and its design can share many characteristics across geographic boundaries. But in the GGH—a densely populated region hugging the western end of Lake Ontario—there are many unique regional factors that necessitate a tailored approach.

For example, Ontario's unique electrical supply is amongst the greenest in Canada, and perhaps globally, yet most households still depend on fossil fuels for over 80% of their energy consumption (primarily for transportation and heating).

The GGH is rapidly urbanizing. It is surrounded by four of the five Great Lakes and in the middle of a confluence of major migratory bird routes. Our population skews younger than most developed economies. These factors, specific to the GGH, are summarized in the following pages.

Population

Young international migrants have been the primary source of growth for the GGH. So much so, in fact, that the senior population (over 65) will peak in 2036 before falling rapidly afterwards. Population growth due to births is also positive in the GGH, unlike the rest of Ontario. Therefore, adequate housing is critical to support the future of our province.

Hydrology and water

Stormwater management is imperative to control flooding and safeguard water quality in the Great Lakes Basin, especially as urban development intensifies. Water conservation and rainwater harvesting will help sustain urban water supplies.

Ecology and biodiversity

Ecological services, including low-impact stormwater management infrastructure, costs less than engineered infrastructure while also providing tangible biodiversity benefits for ecosystems and human communities. Major migratory bird routes, which fly over the GGH, require special attention when designing glazed surfaces to reduce collisions.

> Don't compromise passive measures, durability, or resilience when looking for savings—focus on cutting items that can be easily upgraded in the future.

Economics

Toronto is second only to Vancouver when it comes to the difference between the cost of housing and incomes—and both are far above the Canadian average. While housing starts have fallen behind population growth, it is also important to note that speculators and multi-property owners have been increasingly pricing out individuals and families. And, with construction costs having doubled since 2017, all these factors have fuelled unaffordability across the GGH.

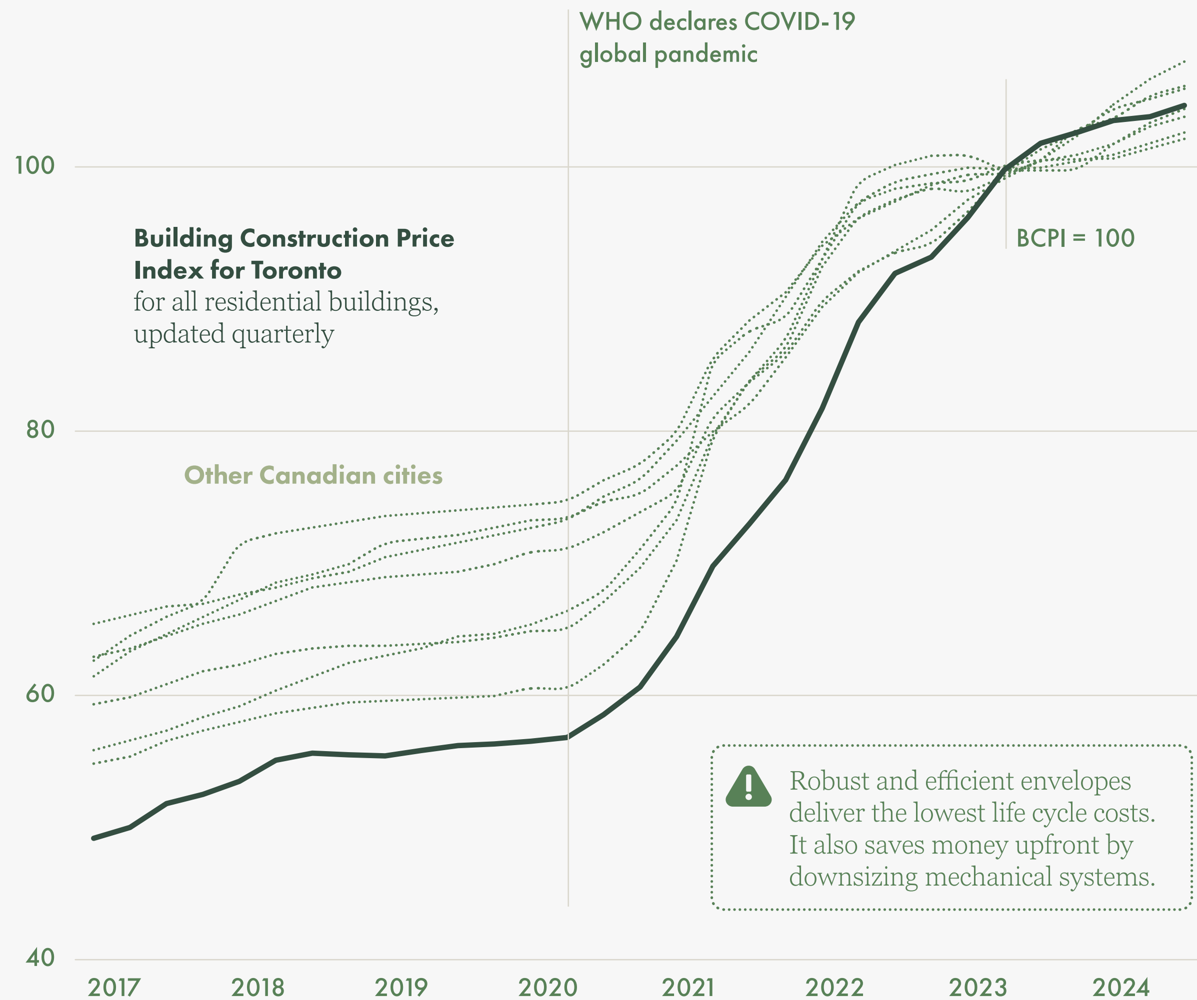
Building regulations and performance standards

Typical codes and standards are slow to adapt, especially in the wake of climate change. Observing progressive building regulations and performance standards in MURB design is key to providing future-ready housing that can outlive outdated regulations.

Precedents in my backyard (PIMBYs)

Did you know that the GGH is already home to some great, home-grown originals? Although they may be few and far between, many exemplary precedents of mid-scale MURBs exist in Toronto, stretching from the early 20th century to today. Many great lessons, specific to the region, can be learned through these existing buildings.

Click here to jump to PIMBYs



> Robust and efficient envelopes deliver the lowest life cycle costs. It also saves money upfront by downsizing mechanical systems.

Expect much more demand for air conditioning and less demand for heating in the future.

Energy and infrastructure

While Ontario boasts a clean electricity grid—amongst the greenest in Canada—there is still a significant expansion of natural gas in new building developments. Over 80% of Ontario's household energy usage relies on fossil fuels.

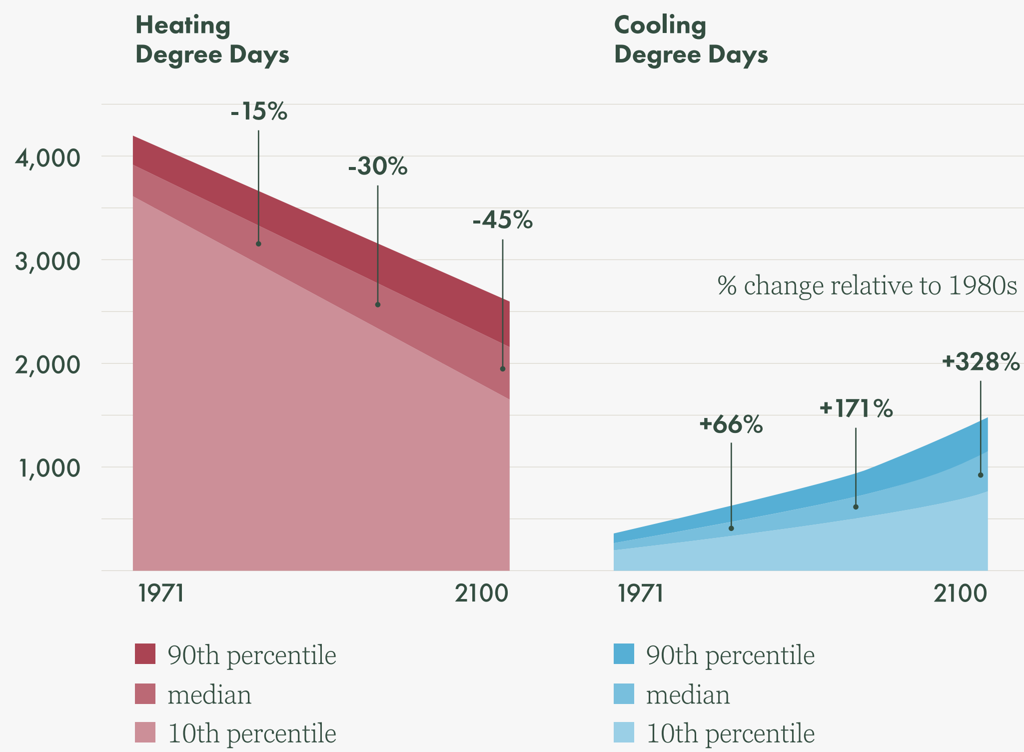
Decarbonizing buildings is most cost effective for new builds, not future retrofit programs. Managing peak energy demands is also critical to curbing the costly expansion of electricity generation infrastructure, as well as reducing operational carbon footprints.

Climate change

Increasing frequency and severity of extreme weather events will challenge the livability of our buildings. Keeping buildings cool will become increasingly critical, changing our usual assumptions for buildings in this region. And a wetter, warmer climate will require durable building enclosures with high drying potential.

Power outages, which are expected to become more common, will challenge the ability for MURBs to provide shelter without active systems.

[Click here](#) to view resources on critical future factors affecting building life cycles.

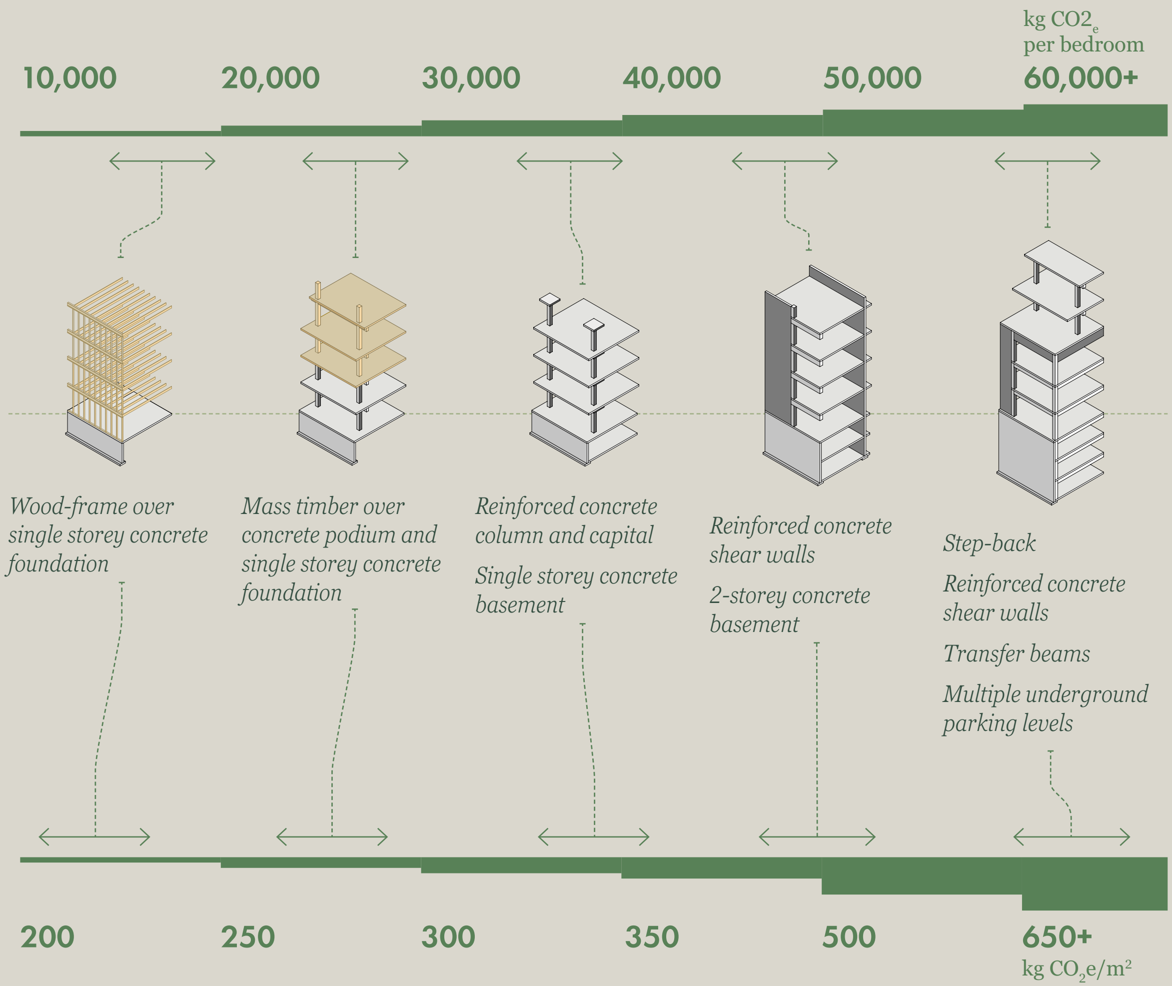


Heating and Cooling Degree Days (HDD/CDD) are the number of degrees above or below 18 °C multiplied by the number of days the temperature isn't 18 °C. It is a useful measure of how much cooling or heating is required.

≠18 °C x number of days

Future-ready design summary

Key carbon and energy performance metrics



Energy efficiency and carbon targets

Energy Use Intensity (EUI)	≤ 100 ekWh/m^2yr
Thermal Energy Demand Intensity (TEDI)	≤ 30 ekWh/m^2yr
Greenhouse Gas Intensity (GHGI)	≤ 10 kg CO2e/m^2yr
Upfront carbon	≤ 350 kg CO2e/m^2 *foundation + structure + envelope*

Passive systems

Minimum envelope effective RSI / R values

Walls	RSI 4.4	R 25
Exposed ceilings and floors	RSI 3.5	R 20
Slab-on-grade	RSI 1.8	R 10
Basement walls	RSI 2.1	R 12
Roofs	RSI 7.9ci	R 45ci
Doors	RSI 1.4	R 8
Windows	Double glazed, low-e, argon-filled, low conductivity edge seal, and thermally broken frames; Provide shading devices	
SHGC of glazing	0.25 - 0.45	
Window-to-wall ratio (WWR)	30% min - 40% max	
Airtightness	<2 L/s/m2 @75Pa *demonstrated in test*	

In the chart above, embodied carbon is based on foundation, structure, and envelope only.

Click here to view examples of green standards from across the GGH.

Systems and resiliency at a glance

Active systems

Space heating and cooling	Ground or air source heat pumps, 4-pipe fan coils
Mechanical ventilation*	ERV *>85% efficient*
Hallway ventilation	< 10 cfm per door w/ energy recovery
Domestic water heating	Ground or air source heat pumps, drain water heat recovery
Lighting and appliances	Highest-efficiency stoves, refrigerators, and lighting
Water conservation	Low-flow fixtures, rainwater harvesting
Peak Energy Demand Management	Individual suite energy metering, schedule EV charging and domestic water heating for off-peak periods

* Provide fully sealed doors and ventilation directly to suites—compartmentalize common areas to control air leakage.

The future-ready design of buildings balances mitigation and adaptation in the face of climate change. In the short term, climate action needs to be a dominant consideration, but it must not overlook other vital aspects of buildings, such as durability and livability. Housing that offers a high quality of life while contributing to healthy and inclusive communities will still be important long after we overcome our present challenges.

Transportation

Automobile parking	Discretionary — based on occupant needs and site context
Accessible parking	10% *of total parking*
Electric vehicles	All parking spaces roughed-in for future EV charging
Car Share	1 *space per 10 suites, minimum 2*
Bicycles	2 *per suite, consider cargo bikes and e-bike charging; provide secure and convenient access*
Para-transit access	Para-transit vehicle access and lay-by parking at main entrance

Resilience and emergency measures

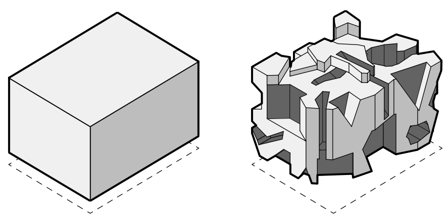
Thermal	72 hours *passive habitability during hot or cold weather*
Flooding	Locate electrical equipment and other critical infrastructure above flood levels
Electricity	Emergency backup electrical generator for safety and critical building services
Drinking water	72 h supply *approx 1 L/person/day emergency drinking water supply*
Place of refuge	Place of refuge for vulnerable inhabitants during extended power outages
House-bound directory	Directory of inhabitants who require assistance to leave their homes
Emergency planning	Emergency response plan and protocols with periodic drills

Landscape, stormwater, green roofs, biodiversity

Planting	Drought tolerant native species; consider phytoremediation potential
Permeability	Locate electrical equipment and other critical infrastructure above flood levels
Stormwater runoff max	Maintain pre-development runoff rates, maximum 50% of annual runoff volumes
Stormwater retention min	Minimum on-site retention of 5mm rainfall event
Hardscape runoff	Capture and control 75% of runoff from hardscaping
Green roofs	Intensive, extensive, bio-diverse green roofs with irrigation (consider rainwater harvesting)
Wildlife protection	Light pollution mitigation, bird-friendly glazing, and planting for pollinators

Design concepts

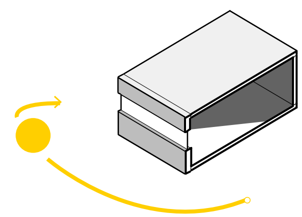
Critical considerations for multi-unit residential buildings



Size and shape

The size and shape of a building largely impacts both embodied carbon and operational energy efficiency. Low form factors (buildings with lower envelope surface area to floor area ratios) combined with fewer corners, joints, and transitions reduce embodied energy and future maintenance requirements. These forms are also less costly to construct.

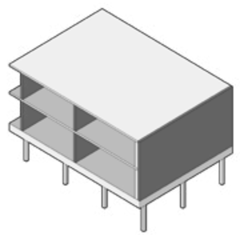
- ✔ Simple is better
- ✔ Reduce corners, joints, junctions, and transitions—this is where leaks and thermal bridging happens



Solar orientation and building envelope

A building's solar orientation, depth of floorplate, and fenestration strategy influence daylighting and natural ventilation. Lower window-to-wall ratios (WWR), more insulation with less thermal bridging, and improved airtightness promote lower heating and cooling energy demands across all climate zones.

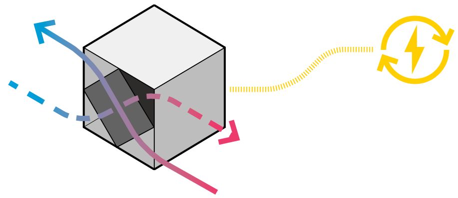
- ✔ Consider your building's orientation and design facades to manage solar heat gains
- ✔ Increase insulation and airtightness
- ✔ Thermal bridging reduces insulation effectiveness—eliminate thermal bridges as much as possible



Choice of structure and materials

The type of structural system has an outsized impact on embodied carbon and cost. Choices for building materials and mechanical, electrical, and plumbing services significantly impact embodied carbon. Efficient structural design and minimizing material quantities reduce costs and embodied carbon. It is always best to avoid materials that contribute to environmental degradation, reductions in biodiversity, and resource depletion.

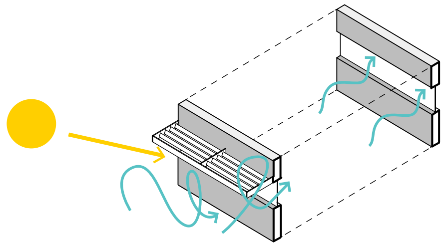
- ✔ Use renewable and carbon sequestering materials, like wood, where possible
- ✔ Avoid over-design of structural systems and specify low carbon concrete and steel
- ✔ Align structural grids to avoid large structural elements like transfer beams



Energy sources and energy recovery

The choice of energy source(s) for operations significantly impacts operational carbon. Maximizing the use of renewable and low-carbon energy sources, which includes reducing energy use during peak demand times through conservation measures. Mechanical ventilation with heat or energy recovery significantly increases operational energy efficiency and reduces peak heating and cooling loads.

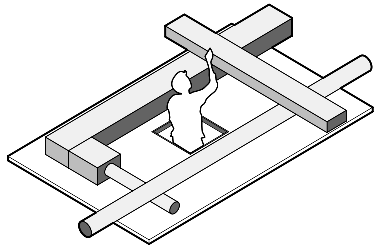
- ✔ Except for emergency back-up generators, avoid fossil fuels in your building
- ✔ Choose all-electric HVAC systems
- ✔ Don't throw away energy with your ventilation—use HRVs or ERVs for to recover as much as possible



Shading devices and natural ventilation

Shading devices and natural ventilation are essential, time-tested passive methods for managing visual comfort and overheating. It is also essential for providing hot weather resilience. These measures reduce cooling loads and operational carbon, while improving comfort and indoor environmental quality.

- ✔ Shading devices provide comfort and an opportunity for visual interest
- ✔ Design rooms and suite layouts that enable cross ventilation



Durability and circularity

Designing for durability and ease of serviceability contributes to building longevity and optimal performance by allowing for proper maintenance throughout a building's lifecycle. Integrating adaptability and flexibility (loose fit) within the building system will also accommodate future adaptive re-use, minimize the risk of obsolescence, and avoid the need for disruptive and costly deep retrofits in the future. Finally, use of renewable and recycled materials, along with designs that account for disassembly, promote circularity.

- ✔ Provide easy access to systems and components that require maintenance
- ✔ Use as many recycled or renewable materials as practical, and where possible design for disassembly

Designing for long life, loose fit, and low impact

Future-ready buildings must be designed as adaptable, long-lasting systems that minimize environmental impact while supporting changing social needs. By integrating strategies for durability, resilience, flexibility, and carbon reduction from the outset, designers can create housing that performs over time—economically, environmentally, and socially.

This section outlines key principles and strategies to guide early design decisions, helping ensure that buildings remain livable, maintainable, and meaningful, well into the future.

> Look beyond the building and consider the neighbourhood. The performance of the neighbourhood is as important as the performance of the MURB.

Much ado about innovation

There is great potential for innovation that builds on the rich history of housing design—it is not an either/or proposition. We should be cautious about innovation for the sake of innovation; after all, the participants in architects' experiments are unknowing residents for decades to come.

Innovation, for housing in particular, arises from the clever and thoughtful balancing of site-specific criteria. In this guide, we propose the following parameters as the building blocks of future-ready MURB design:

- morphology;
- materiality;
- metabolism;
- economics;
- livability; and
- stewardship.

This section of the guide provides some key insights on each of these six parameters with links to downloadable resources that contain specific and more in-depth information.

However, before exploring each of these aspects, it is important establish a guiding framework for future-ready architecture.

The 3-Ls

Future-ready, or sustainable architecture, is generally understood to observe the 3-Ls:

Long life
durability, resilience, persistence

Loose fit
adaptability, flexibility, contingency

Low impact
emissions, ecological footprint

Long life

A building's lifespan has many dimensions—durability, resilience, and persistence among them.

Durability refers to how long materials, assemblies, equipment, and fixtures last before needing repair or replacement. Service lives vary widely; while fixtures and finishes may need regular updates, the building's core structure—its foundation and frame—typically lasts much longer. In Canada, the CSA S478:19 Durability in Buildings standard outlines normative service lives for different building types and components.

Durability also takes on deeper meaning when viewed through an environmental lens. As one definition puts it, "from a sustainability perspective, a material, component or system can only be

Low-density greenfield developments are ecologically and financially unsustainable, costing far more to service than their urban counterparts.

considered durable when its service life is fairly comparable to the time required for related impacts on the environment to be absorbed by the ecosystem." In that sense, durability isn't an absolute—it's a relative measure that requires thoughtful contextualization by the designer.

Resilience speaks to a building's ability to absorb shocks and recover from disruptions—particularly in the face of extreme weather. If a building fails to maintain performance during climate events, it can't be considered resilient. In building science terms, "performance" refers to how well a material, assembly, or system delivers a defined level of service—like providing safe, habitable shelter.

Persistence is about a building's capacity to stay in use over time. That means being capable of retrofit, reuse, or re-purposing in response to shifting social, economic, and environmental needs. Toronto's brick-and-beam buildings are a case in point—they've persisted for more than a century, adapting from industrial to commercial to residential use.

In simple terms, a long-life building lasts longer than the time it takes for the natural environment to recover from the impacts of its creation. That's the threshold we should be aiming for.

Loose fit

Designing housing with a "loose fit" means planning for adaptability—from the scale of individual units to entire buildings. Units should be able to accommodate a range of household types, including multi-generational families, aging-in-place, or communal living. Adjacencies matter too: suites should be easily combined or divided to meet changing household needs. Flexibility can also mean allowing rooms—like bedrooms or living areas—to be partitioned for privacy when needed.

To support an uncertain future, architecture must make space for contingency. That might mean room for movable partitions, built-in storage, foldaway beds, or other interventions that allow living spaces to flex over time. It also includes things like increased floor-to-ceiling heights, which make future upgrades to mechanical, electrical, or plumbing systems easier and less disruptive.

A loose fit extends the lifespan of housing by supporting a wider range of household compositions and life stages. It is a key ingredient in creating more equitable and enduring forms of domestic life.

Low impact

Buildings, in their construction and operations, have wide ranging impacts, such as carbon emissions, air and water pollution, resource depletion, environmental degradation, and reduction of biodiversity. Design choices can lessen this impact.

Material choices matter: foundations and structural systems represent some of the highest carbon loads in a building, making their efficient design and material use critical. Circularity should guide the physical makeup of buildings, emphasizing renewable, recycled, reused, and locally sourced materials wherever possible. These strategies aren't just environmentally responsible—they're foundational to lowering embodied carbon at scale.

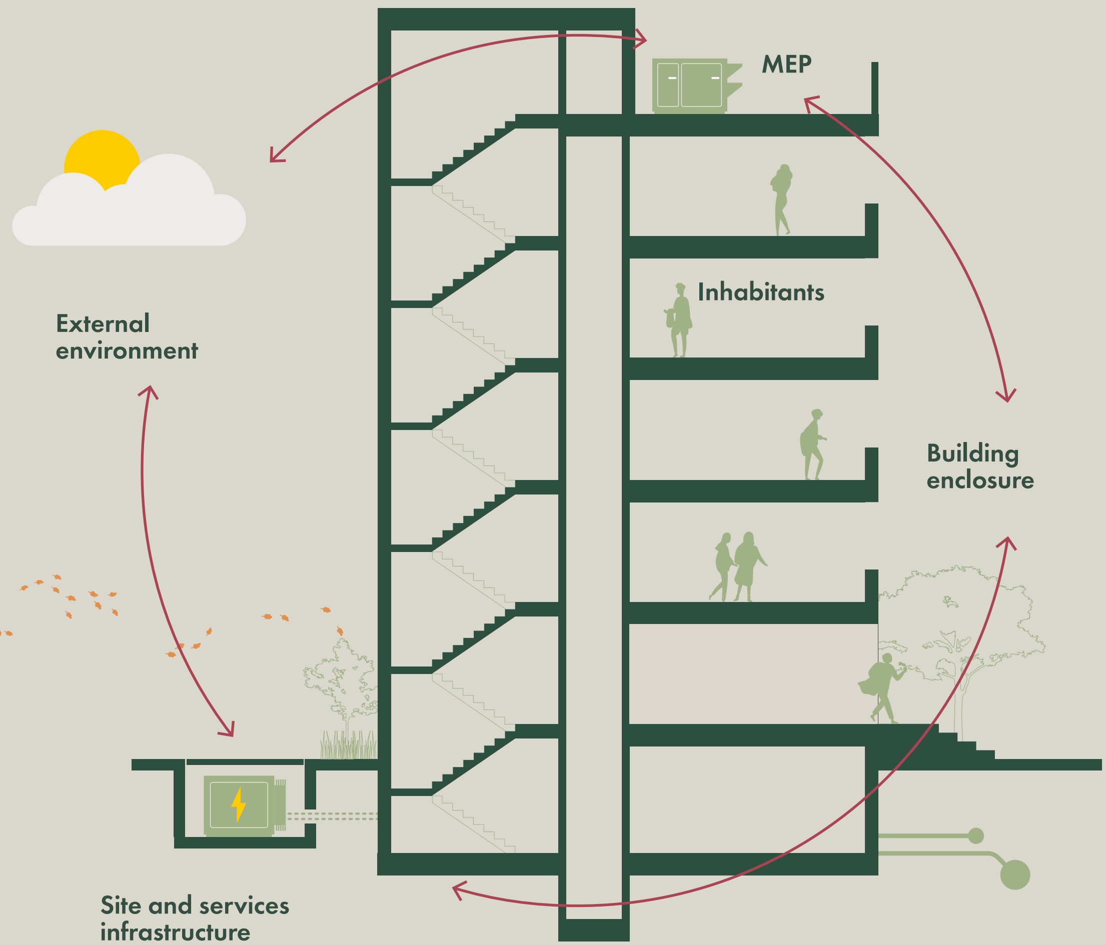
Location is just as important. Recent studies, including a report commissioned by the city of Ottawa in 2023, reveal that low-density developments on the urban fringe result in net servicing costs, versus high-density urban developments which can net surplus. Future-ready housing should prioritize intensification in areas where infrastructure already exists—leveraging transit, utilities, and community services to build more complete, resilient communities.

Building-as-a-system

A systems thinking approach emerged as building science began mapping interactions between parts of the *building-as-a-system* model. It is an important framework for integrating the 3-Ls by nesting systems at the building and site scale.

The *building-as-a-system* model emerged in the 1980s, when proven practices were often abandoned in favour of untested materials and methods. Building science stepped in to reconnect the dots—linking the external environment, passive and active systems, site infrastructure, and, critically, the occupants. Evidence showed that comfort improved not when design dictated behaviour ("hard" design), but when people were given control over temperature, ventilation, and daylighting. This marked a shift to "soft" design—buildings that respond to their users.

Yet comfort alone doesn't make a building future-ready. Buildings may look static, but they are always changing—adapting to new technologies, climates, and social needs. Designing for resilience means understanding how each layer of the system interacts over time. When done well, this approach produces buildings that last longer, feel better, and tread more lightly. In other words: *longevity, livability,* and *low impact*—the three Ls of future-ready design.



> Buildings aren't objects frozen in time—always design systems that can evolve with people, place, and climate.

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Building layers

Hard to change
Form
Fabric
Fit out
Fixture
Finish
Furnishings
Easy to change

→→→→ **Fast rate of change**
⟶ **Slow rate of change**

Surroundings
Landscape, development, densities and demographics of the precinct where the building is situated.
variable

Skin
Cladding, fenestration and control layers for heat, air, and moisture management.
20-75 years

Structure
Foundation, wall, floor and roof components including bracing, elevator and stairwell cores.
100-300 years

Space
Looseness of fit in the packing of services (access, maintenance, replacement)
integral

Services
MEP including telecom, vertical transportation, HVAC system plus site infrastructure such as building sewer, potable water supply, etc.
10-50 years

Space plan
Layout of program elements and amenities, internal circulation including access/egress and vertical transportation, plus interior fit out.
3-30 years

Stuff
Personal belongings, clothing, food, furniture, appliances, etc.
days, months, years

Site
Earth supporting the building, the property where the building is situated.
∞ *eternal*

The arrangement and harmonization of building layers is key to observing the 3-Ls for the life cycle design of buildings.

A building is more than a static object—it's an artifact shaped by its surroundings and embedded in a social and cultural context that is constantly evolving. To remain resilient over time, it must be designed with that change in mind.

Modern buildings are made up of layers, each with its own service cycle—the period during which it performs reliably before requiring maintenance or replacement. Ideally, the components within each layer should have similar life spans, and interconnected layers should be coordinated so their service lives are multiples of the least durable one. This allows for maintenance to be planned on a regular schedule, rather than addressed piecemeal.

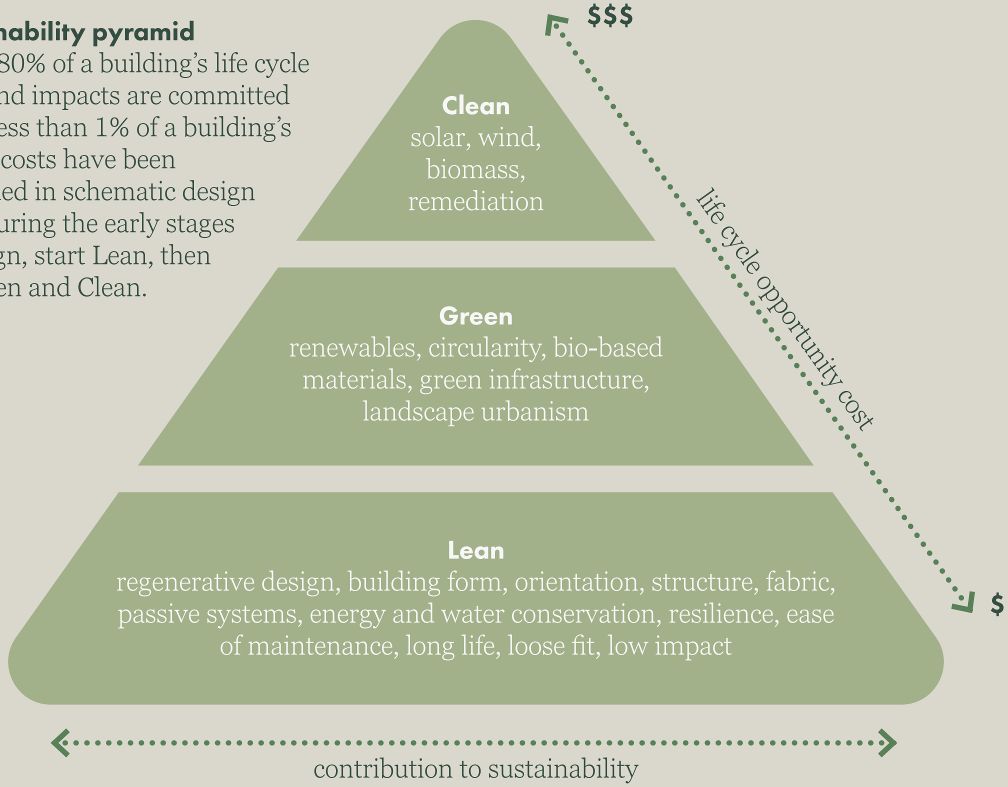
When service cycles are aligned, it reduces disruption and cost, avoiding repeated set-ups for staging (such as scaffolding). It makes long-term budgeting more predictable for building owners, housing providers, and public agencies. Harmonizing these layers isn't just good practice—it's essential to delivering a building that's manageable, maintainable, and built for the future.

Initial work by Brand[1], subsequently augmented by Schmidt and Austin[2], revealed that nine layers of the building-as-a-system determine its DNA and ability to adapt to changing needs and contexts.

The life cycle impacts of a building and its useful service life are predominantly determined by its DNA as conceived during the early stages of design.

Sustainability measures hierarchy

Sustainability pyramid
Often, 80% of a building's life cycle costs and impacts are committed when less than 1% of a building's capital costs have been expended in schematic design fees. During the early stages of design, start Lean, then go Green and Clean.



Prioritizing lean measures early in design delivers the greatest impact for the lowest cost—offering more leverage than Green or Clean strategies over the building's life cycle.

The 3-Ls constitute the basis of Lean design strategies and deserve priority over *Green* and *Clean* measures.

Not all sustainability measures are created equal—especially when considered over the full life cycle of a building. Opportunity costs reflect the long-term economic leverage of decisions made during design and construction. Some choices have a lasting impact on operational costs, maintenance, and emissions, while others offer only marginal returns.

Sustainability strategies are often grouped into three categories: Lean, Green, and Clean. Among these, Lean measures—those that reduce complexity, material use, or building size—offer the greatest potential to lower life cycle costs. Green measures, when integrated with a Lean design approach, help minimize environmental impacts associated with construction. Clean technologies, while valuable, often contribute less in comparison, offering incremental gains rather than transformational ones.

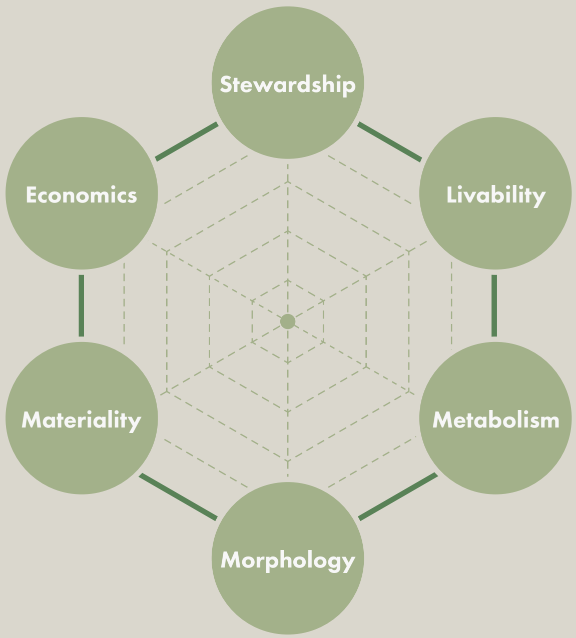
Maximizing value means investing early in strategies with the highest leverage. Decisions made at the outset will shape not only how a building performs, but also how costly—or how resilient—it will be over time.

Design strategies

Six key parameters for MURB design

Balancing these key design parameters must be reconciled to deliver housing that is safe, healthy, functional, beautiful and sustainable. While climate action and adaptation are a major part of future-readiness, they are not the only priority for MURBs.

These parameters guide the design strategies found on the following pages.



1 *Morphology:* Effective housing design considers form, layout, and adaptability. Building forms—whether slab, block, tower, or courtyard—must align with their context, while layouts, such as single- or double-loaded corridors, optimize circulation. Flexibility in structural systems, clear spans, and floor-to-floor heights ensures buildings can adapt to changing needs over time.

2 *Materiality:* This encompasses every element of a building, from foundations, structure, and enclosures to interior finishes and fixtures. Mechanical, electrical, and plumbing (MEP) systems, along with landscape and site infrastructure, must be thoughtfully selected to balance performance, sustainability, and long-term durability.

3 *Metabolism:* Housing must balance energy use and minimize its ecological footprint by addressing operating energy, embodied carbon, and recurring emissions. Designs should integrate passive and active systems to achieve thermal autonomy, enhance daylighting, and support natural ventilation, while ensuring resilience to environmental challenges.

4 *Economics:* Housing design must balance initial costs, affordability, and long-term financial performance. Operations, maintenance, durability, and resilience are critical to extending service life and preventing functional obsolescence. Life cycle costs should guide decision-making to ensure sustainable and economically viable solutions.

5 *Livability:* Livable housing prioritizes accessibility, essential amenities, and strong community connections. Proximity to public transit, services, and recreation ensures homes are both functional and well-integrated into their surroundings.

6 *Stewardship:* Housing design should protect the environment, manage infrastructure efficiently, and foster community integration. This includes addressing stormwater, solar access, biodiversity, transportation, and energy, as well as fostering civility and belonging.

Morphology

Mid-rise urban building design is shaped by the interplay of morphology, typology, and site conditions within a layered regulatory landscape.

Historic land platting, evolving zoning, and shifting attitudes toward parking all influence what's feasible. As cities transition away from car dependency, architects are rethinking how to deliver dense, resilient housing that enhances neighbourhood livability.

The spaces and relationships that are created between adjacent buildings and their residents are just as important as the layout of the housing and site landscaping.

Click here to view resources on urban morphology and housing types.

Morphology vs typology

Building morphology examines the physical form and spatial organization of buildings—including their overall shape, internal configuration, and relationship to the surrounding environment. It considers aspects such as structure, design, and geometry, and how these elements influence a building's function and aesthetic.

Building typology, by contrast, is the classification of buildings based on their defining characteristics. Typologies can be functional—organizing buildings by primary use (residential, commercial, institutional)—or formal, grouping them by visual or structural traits like circulation patterns, layout, entry conditions, and site relationships.

While typology categorizes buildings, morphology looks at the characteristics and processes that shape their physical form.

The morphology of MURBs is broad and varied. Even within the GGH region, there is a wide range of apartment buildings spanning different scales and typologies. However, this guide is not intended to explore morphology or typology from an academic perspective. Instead, the focus is on evaluating the feasibility of specific MURB designs in relation to a given parcel of land. The goal is to make the most efficient use of land and existing infrastructure to deliver high-quality housing that is durable, resilient, and energy-efficient—while minimizing ecological footprint.

All Shapes and Sizes - From walk-ups to towers, the GGH is home to a variety of MURB designs that range in era from over a century ago to the present. The high cost of land and our current regulatory framework do not allow all of these variations to be viable, especially for infill sites constrained by neighbouring buildings. Innovative design solutions are needed that achieve all the performance requirements we now impose on MURBs. Choosing an appropriate shape and massing for a building is an important early stage design decision.

Land assembly and planning context

The act of creating a plan, map, or diagram that divides land into lots, streets, and other features is known as land platting.

In the GGH, this practice dates back to European colonization, when British military engineers and surveyors implemented the land platting system. Their work laid the foundation for many of the subdivision plans that shape our cities, towns, and rural areas today.

These historic layouts have since been layered with zoning, planning policies, and municipal by-laws—each reflecting evolving cultural norms and planning priorities. Together, these frame-works form a complex set of conditions that must be navigated when assembling land for a viable MURB development.

Developers and housing agencies must begin with a general sense of the type of MURB they intend to build. Once a potential development envelope and candidate typology (e.g., a 4-storey walk-up or 8-storey mid-rise) are identified, the schematic design process can begin. A number of critical considerations will shape the evolution of the design, and several of the most impactful ones are outlined in the following pages.

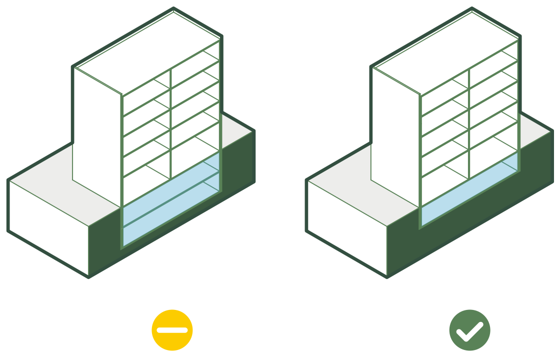
What's next for parking?

Their introduction of the car just over a century ago has had a huge impact on just about every aspect of how we plan and build our cities, from the devel-opment of suburbs to the highway infrastructure required to support them.

In the case of MURBs, the storage of cars can have an outsized impact on the building's structural design, environmental impact, and overall cost. How and when we incorporate parking affects a wide variety of issues including how a building meets the street, the type of units available on the ground floor, and the choice of structural system and waterproofing requirements.

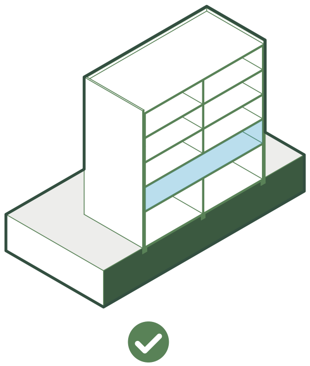
Car dependency has been baked into the DNA of many of our GGH communities. Addressing this issue will require decades of investment and politi-cal will—beyond the scope of this guide. There are, however, certain design principles that architects should consider when thinking about parking to minimize its negative impact.

Parking lots in downtown Toronto - *City of Toronto Archives, Series 1465, File 59, Item 5*



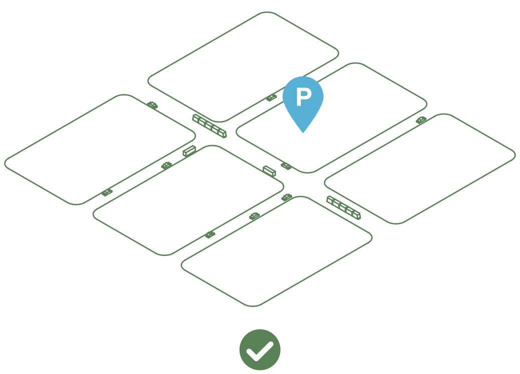
Avoid multi-level underground lots

If there are no other options, restrict parking to only one level below grade.



Elevated parking

Parking can be located on the 2nd floor and above, reserving the ground floor for other uses. This also allows for parking to be re-purposed, later.



Consider district lots

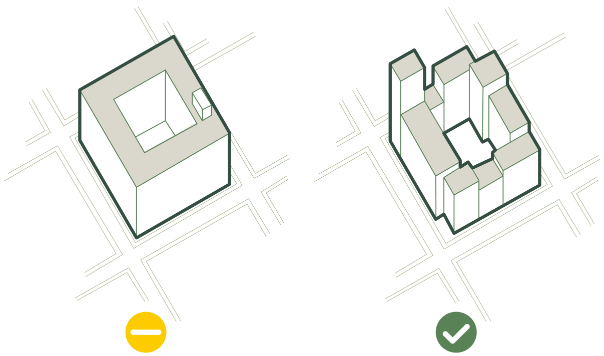
When there is an opportunity to do so, share district parking lots amongst multiple buildings.

Parking strategies

Site specific: While car-dependency might be widespread in the GGH, parts of our region also boasts some of the most frequent public transit in the continent. How much parking to include—if any at all—should be a decision based on location.

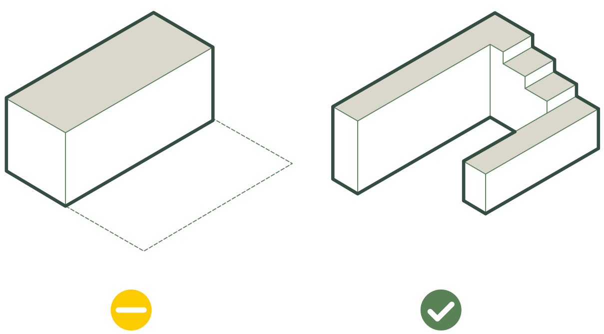
Future-ready flexibility: Even when parking is required, there are design choices that can be made to allow for a less car-dependent future. Avoid underground parking: placing parking on the second floor or above allows for easier conversion to future uses. Fully sloped slabs should also be avoided for the same reason. Instead, using ramps to connect flat floor slabs encourages future flexibility. The ground floor, however, should be reserved for uses that will animate the street, such as retail or accessible units.

Accessibility: Even when parking requirements have been significantly reduced, some level of parking may be required to ensure equal access for individuals with different abilities. Design the front of the building to safely accommodate drop-offs and pick-ups by services such as Toronto's Wheel-Trans, improving overall building accessibility and independence from automobiles.



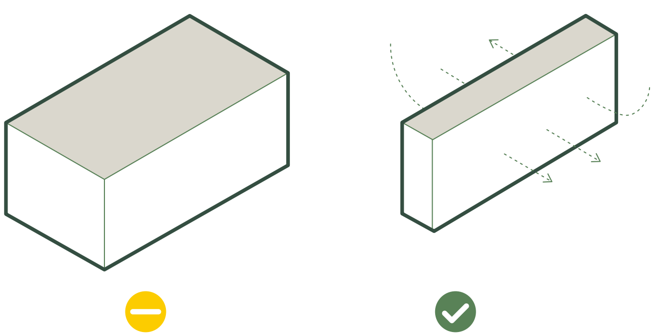
Think about scale

Large buildings should resolve at a human scale, especially where they meet the street.



Enclose space

When given the opportunity, use a building's mass to enclose a quiet zone for residents.



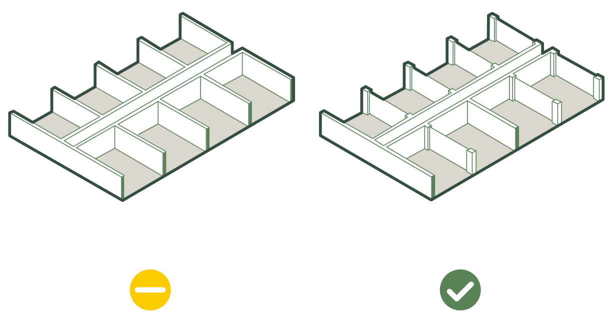
Thinner is better

Thinner building forms with shallow floorplates give each unit better access to daylight, views, and fresh air.

Geometry

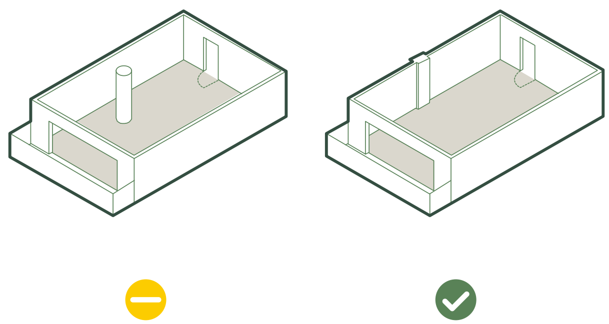
Buildings with complex geometries and multiple step-backs are generally more difficult and expensive to construct. They also increase the odds of water leakage and maintenance requirements at junctions and transitions.

Step-backs require more supporting structure that increases the amount of material and embodied carbon in the building. How buildings are shaped, and in turn, how they shape the spaces within, between, and around them, affect the quality of the urban realm.



Minimize shear walls

Shear walls make buildings very difficult to adapt. Instead, use slabs with columns and non-load-bearing partitions, which are much easier to modify.



Integrate columns

Columns should form part of walls and other demising structures, rather than encroaching on resident space.

Structural system

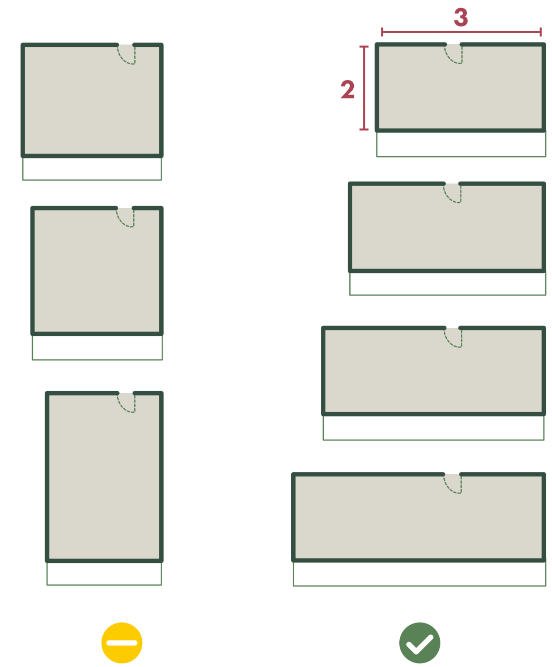
Structural systems represent a significant proportion of a building's carbon footprint. The use of shear walls as demising walls in reinforced concrete structures carries a high carbon footprint. It also makes the building difficult to adapt to future internal reconfigurations.

Slabs supported by columns and drop panels provide greater flexibility in the location and arrangement of demising walls—and a lower embodied carbon content by using less reinforced concrete. In wood, steel and concrete structures alike, it is important to optimize clear spans to enable a greater variety of suite layouts.

About shear walls...

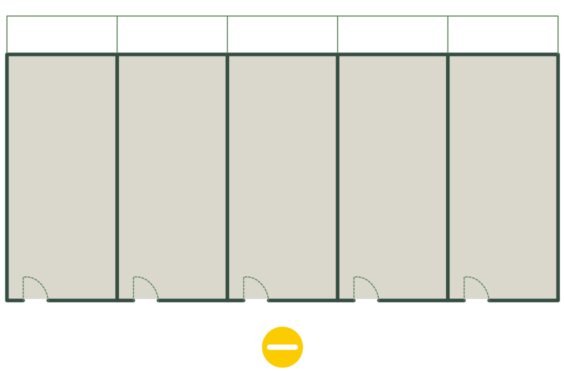
Using shear walls that also serve as demising walls is commonplace in GGH MURB construction. However, such walls make future adaptation very difficult if not unfeasible.

Columns supporting slabs with drop panels can have fire-rated demising walls constructed in a variety of configurations. These demising walls are easily disassembled and moved as required to accommodate future needs.



Wider is better

A minimum suite aspect ratio of 2:3, with the long side facing the exterior, provides greater access to light and air.



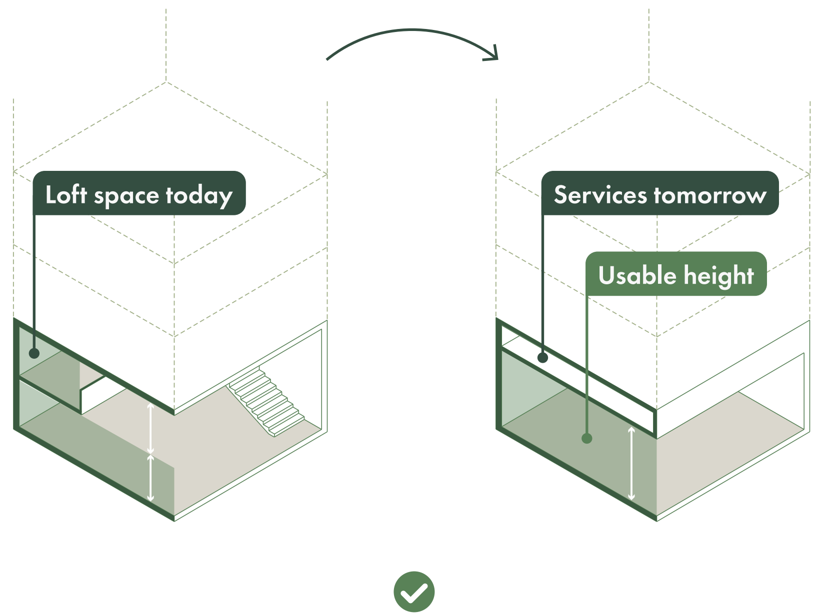
Avoid shoeboxes

Shoeboxes, where units are arranged side by side with the short end facing the exterior, should be avoided.

Suite aspect ratios

The aspect ratio of suites refers to how wide or deep a particular unit is (depth:width). A minimum suite aspect ratio of 2:3, which is 1.5x wider than it is deep, provides desirable sunlight and cross ventilation capability.

Of course, suite aspect ratios affect the overall size and shape of MURBs. Compared to smaller-scale buildings with shallow footprints, deep buildings often present a more imposing and less welcoming face to the public realm.

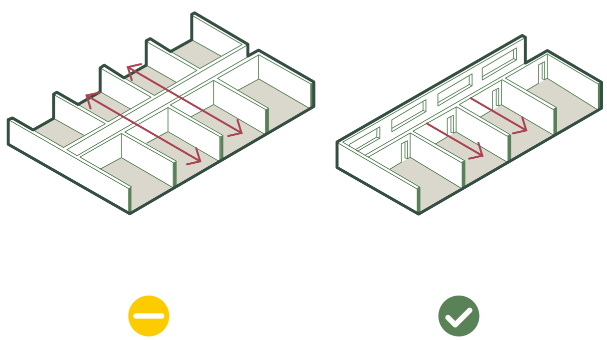


Ground floor height

Sufficient ground floor heights can provide future flexibility for adaptive reuse. For example, internal mezzanines can initially serve as loft housing and become commercial or institutional space later.

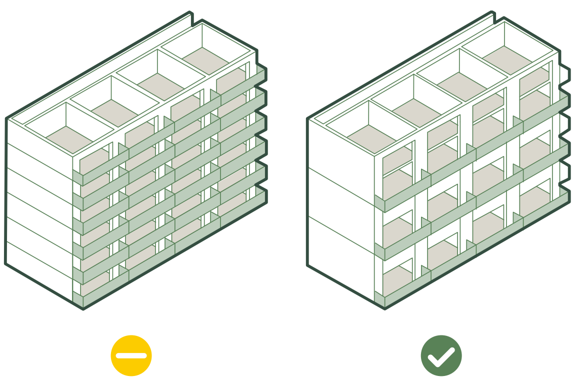
Higher ground floor heights allow for the practical retrofitting of MEP or IT infrastructure through raised floors or dropped ceilings, without compromising on ceiling height.

But we should also be careful not to create overly tall ground floors, which can be wasteful and disproportionate.



Single-load where possible

Single-loaded corridors provide far superior access to sunlight and fresh air, improving livability significantly.



Skip-stop plans

Skip-stop plans allow for highly efficient access to air and light. Access corridors and elevators stop on every other floor, providing more area to suites. Double-height balconies allow deep penetration of daylight.

Single- and double-loaded corridors

Double-loaded corridors typically serve single-aspect suites, where units have windows on only one exterior wall. This common configuration maximizes efficiency but limits access to daylight and natural ventilation. In contrast, single-loaded corridors run along one side of the building, allowing suites on the other side to benefit from windows facing outdoors. This setup can act as a buffer between private units and more public or service areas, while still supporting natural light and ventilation within the suites.

Accessibility

While skip-stop schemes are spatially efficient (by reducing corridor area), they are inaccessible to those with mobility issues. Buildings organized this way should provide a variety of unit types that can accommodate diverse disabilities.

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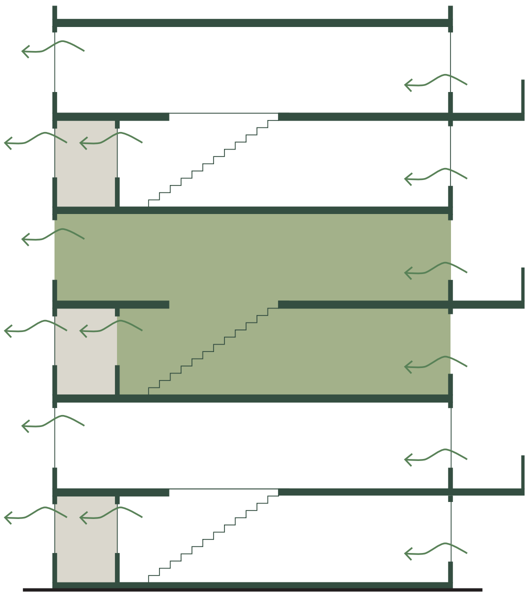


Double aspect facades

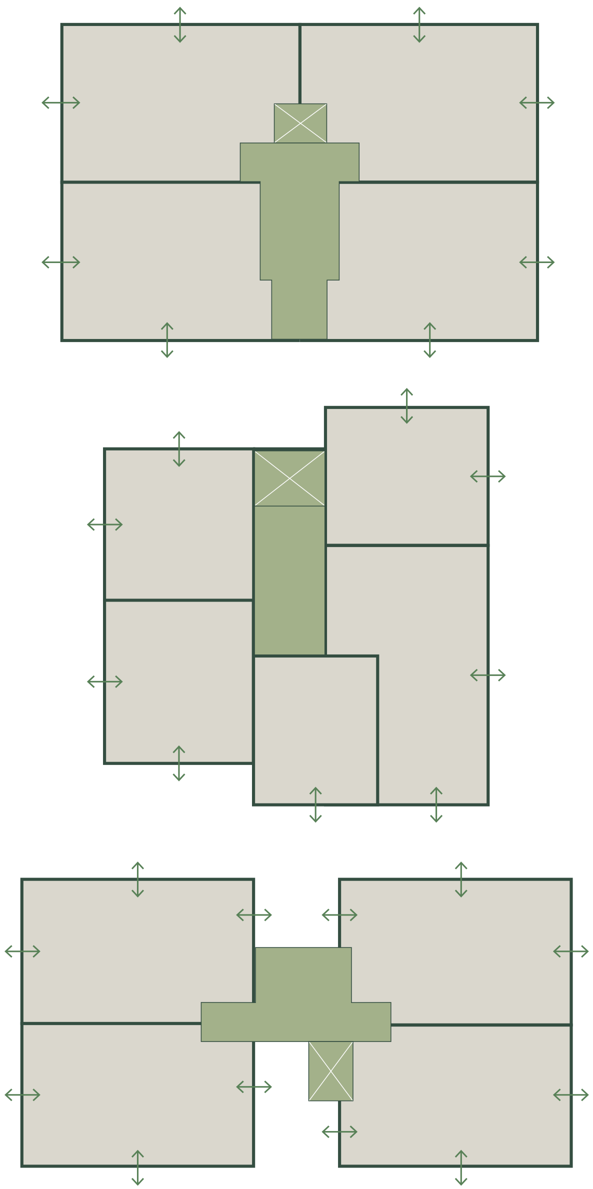
Design building layouts that allow ventilation and light on more than one side of a suite. Two-storey suites provide even more ventilation by enabling convective currents.

Single- and double-aspect facades

A single-aspect facade has exterior walls and windows on one side only. This makes it difficult to provide adequate daylighting and natural ventilation to the entire suite, especially in deep floorplates. Double-aspect facades have exterior walls and windows on two sides—for example, in a corner suite or on opposite sides when a single-loaded corridor is deployed. Double-aspect facades provide far superior daylight distribution, cross-ventilation, and overall environmental quality.

Privileging daylight and passive ventilation

Two-storey suites served by skip-stop single-loaded corridors provide an ideal section for ventilation and daylight. Two-storey suites enhance hi-low cross ventilation, taking advantage of the buoyancy of warm air.



Single point stairs enable multi-aspect facades

Single point access stairs can provide small apartment buildings with double- and even triple-aspect facades, giving ample daylight and effective natural ventilation.

Currently, single point access stairs are being proposed for MURBs up to 6 storeys, with compensatory sprinklering and smoke protection measures.

Exit stair & corridor

Elevator

[Click here](#) to view resources on building fire safety design.

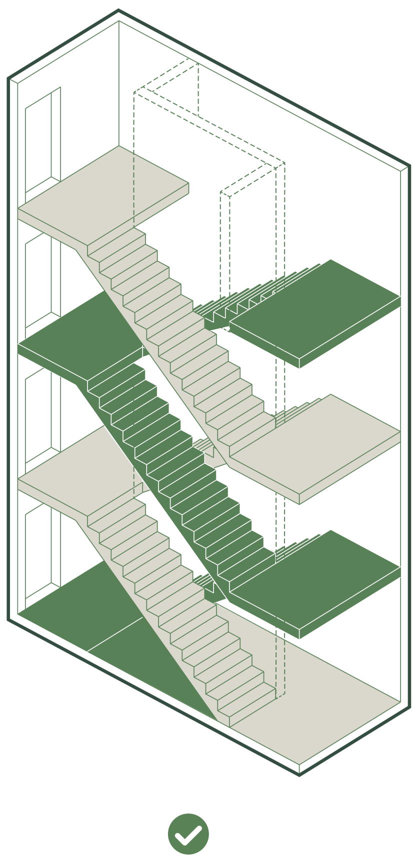
All about stairs

The potential for maximizing the number of suites with double-aspect facades is often compromised by code requirements for means of access and egress. Currently, MURBs taller than two storeys necessitate at least two means of egress, affecting the layout and configuration of many smaller and mid-sized apartment buildings.

If current proposals for alternative solutions under the code are accepted, this has the potential to significantly enhance the indoor environmental quality of smaller-scale MURBs. It will also make them less expensive to construct by using floor space more efficiently.

Point access stairs

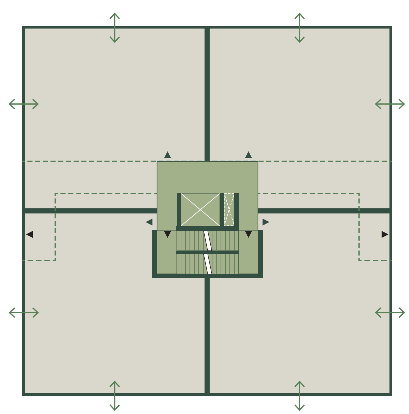
A point access stair refers to a single stair that directly serves a small number of units per floor, typically without the need for a shared corridor. Common in many international jurisdictions, this approach is often permitted in mid-rise buildings and supports more efficient, compact layouts. By eliminating long hallways and second stairs, it becomes easier to design double-aspect suites. Using the space more efficiently makes building mid-sized housing more financially feasible, and thus more affordable for residents.



Scissor stairs

Scissor stairs are the most space efficient way of achieving two means of egress and have been common throughout the history of MURBS in the GGH.

Ground floor egress

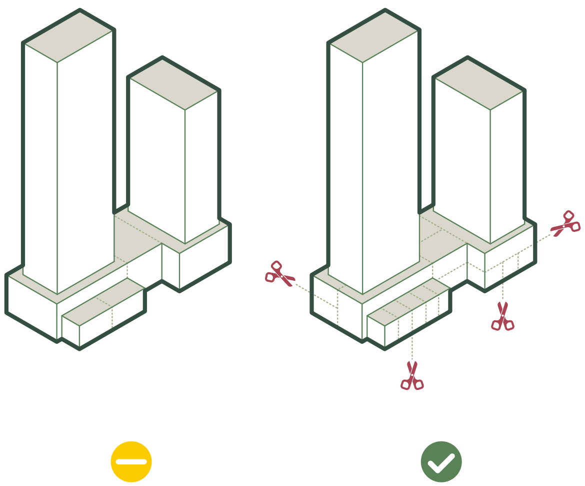


Circulation efficiency

Until the OBC allows for single-stair or point access configurations in mid-rise buildings, scissor stairs remain one of the most effective strategies for creating compact, efficient floorplates while meeting the requirement for two means of egress. By interlocking two stair runs within a single core, scissor stairs reduce the amount of space dedicated for vertical circulation. This frees up more of the floorplate for units, enabling better daylight access, double-aspect layouts, and improved natural ventilation.

When carefully detailed—with proper fire-rated separation and clear exit path markings—scissor stairs are fully code-compliant and have been successfully used in a number of existing MURBs in the region.

While they may introduce some complexity in construction and wayfinding, their spatial efficiency and potential for higher-quality unit design often outweigh these concerns. In an urban context where every square metre matters, they offer a pragmatic middle ground between conventional double-loaded corridors and the more progressive—but currently unpermitted—single stair approach.



Subdivide podiums

Smaller, more flexible units are easier to lease and create a more diverse and enjoyable streetscape. Consider innovative public uses that can animate podiums while commercial units await occupancy.

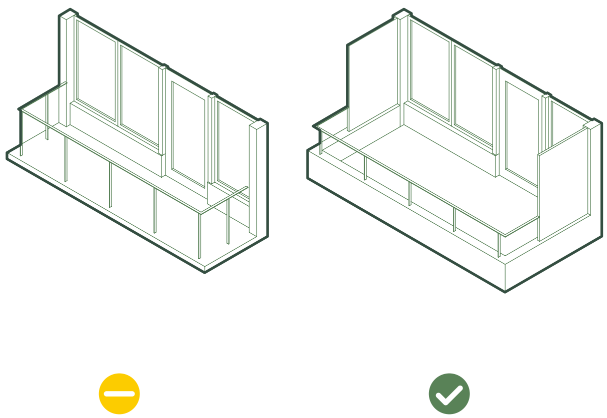
Mixed-use buildings and podiums

The GGH has seen a large number of mixed-use developments where a residential tower is situated above a commercial podium. Mixed-use buildings hold the potential to enhance amenities for residents and the community at large. Planning policies reflect this ambition.

However, all too often these podiums are insufficiently subdivided, stripping streetscapes of their granularity and leading to long-term vacancies (as property owners struggle to lease large spaces). Smaller, more human-scale commercial frontages encourage interaction and animation around the podium perimeter, improving habitability and safety for everyone. For these reasons, adaptable schemes that can be easily subdivided to attract a diversity of tenants is recommended.

The earlier, the better

It may take years to fully occupy a podium, leaving a dead zone on the street until tenants are secured. Flexible podium design, which could allow for innovative public uses, can provide street life until fit-outs occur.



Space for living

Great balconies, terraces, and rooftops are well-connected, adequately sheltered, and sufficiently sized for furniture and everyday life.

Balconies, terraces, and rooftops

Some aspects of MURBs are shared with the city—others are hidden from view, reserved for the people who live there. Balconies, for example, are part of the streetscape. Pedestrians see them, but only residents use them. Terraces and rooftops, on the other hand, are typically private—access is limited, and often only a few people get to enjoy them. Still, these elements have a big influence on how a building looks, and in turn, how a street feels.

What about thermal bridges?

There has been a recent trend to eliminate balconies entirely to avoiding thermal bridging. Thermal breaks or other strategies add cost. But choosing to omit balconies for that reason alone prioritizes short-term savings over long-term livability. As we move toward low-carbon building targets, we need to find ways to do both: reduce emissions and preserve access to private outdoor space.

Materiality

Material selection plays a pivotal role in shaping a building's environmental footprint, often more so than how it's built. Using less material by building less, reusing materials and applying fewer finish materials are the most effective means of addressing materiality.

Architects must navigate complex trade-offs—durability, carbon, ecological impact, and circularity—to make informed, future-forward choices. Responsible design means treating materials not just as elements of form, but as agents of long-term resilience and ecological stewardship.

Click here for the Living Building Challenge's *Red List* of "worst in class" chemicals prevalent in building materials.

Material choice is highly consequential

It is important to recognize that the environmental impact of material choices far exceeds that of construction methods. Following morphology and typology, materiality is the next most meaningful consideration from an ecological perspective.

Architects have many choices when it comes to the materials that make up their buildings. Some materials imply a specific method of construction—load-bearing masonry, for example—while others, like structural frames, can be executed in wood, steel, or reinforced concrete.

The taxonomy of building materials and construction methods is both extensive and diverse. Raw materials drawn from the earth usually require vast amounts of energy and water to extract, process, and manufacture into the many components, assemblies, and systems that form our buildings. While construction methods involve labour, tools, and equipment, these account for only a small fraction of the upfront environmental impacts.

Key Factors

To make informed material choices, we must understand the range of impacts associated with materiality in buildings, and their significance relative to one another. The following factors need to be carefully assessed at the early stages of design:

Durability: This can be expressed as multiple attributes, such as useful service life, persistence of service quality, required maintenance, and functional obsolescence. If a material is not fit for its intended use, then it cannot be considered no matter how green it may be.

Carbon intensity: The GWP or embodied carbon footprint associated with the extraction, processing, manufacturing, and transportation of the material or product.

Ecological footprint: The sum total of stresses on the ecology, including impacts on resource depletion, reduction in biodiversity, and environmental degradation.

Circularity: The minimization of waste, the maximization of recovery, reuse, and recycling, and the privileging of renewable and bio-based materials. In the context of building, circularity means designing, using, and reusing materials to minimize waste and maximize value throughout a building's life cycle.

Design tactics

Materiality strategies are most effective when coupled to a larger set of design tactics that help prioritize the responsible selection of materials, components and assemblies. The 5-Rs is a design hierarchy that be implemented to economically reduce the ecological footprint of buildings while promoting their sustainability.

Making good material choices should not be compromised by the wasteful use of resources. For example, the use of low embodied carbon alternatives to conventional material choices (e.g., low carbon concrete) should still be coupled to the principle of sufficiency where no more than is necessary is utilized. At the same time, providing some additional strength or structural capacity to accommodate future changes to a building may be quite prudent. These sorts of design dynamics are best informed by looking at the building as a system through a life cycle lens in order to keep materiality in perspective.

The five Rs

The inverted pyramid of design tactics represents the most time and cost-effective means of promoting circularity in material choices as well as building design, with the most optimal strategies at the top.

Rethinking contemporary housing design has the lowest ecological footprint and is the most impactful first step. The subsequent tactics incur increasing allocations of time and cost resources. But these are still much lower than the life cycle costs and environmental impacts associated with conventional, contemporary MURBs.

Rethink building design and question the status quo, business as usual, and the linear economy.

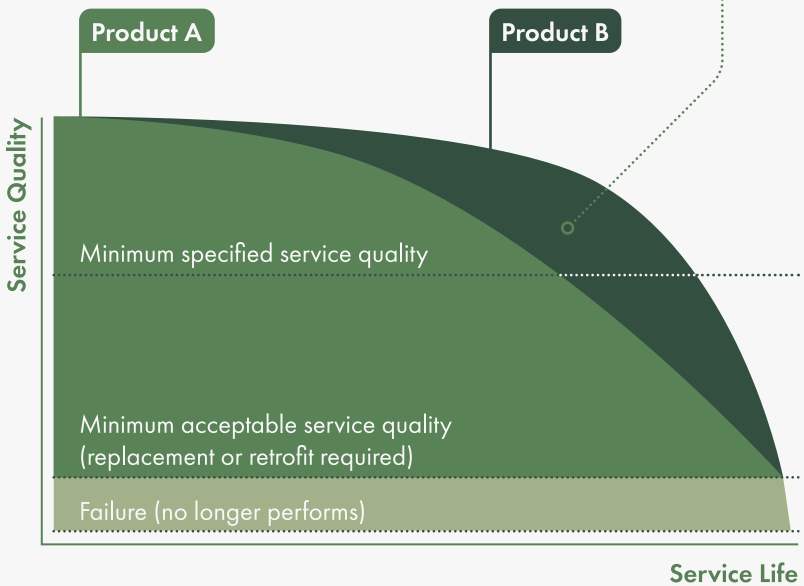
Refuse (or restrict) non-circular materials, components, assemblies, equipment, and fixtures to the greatest extent possible.

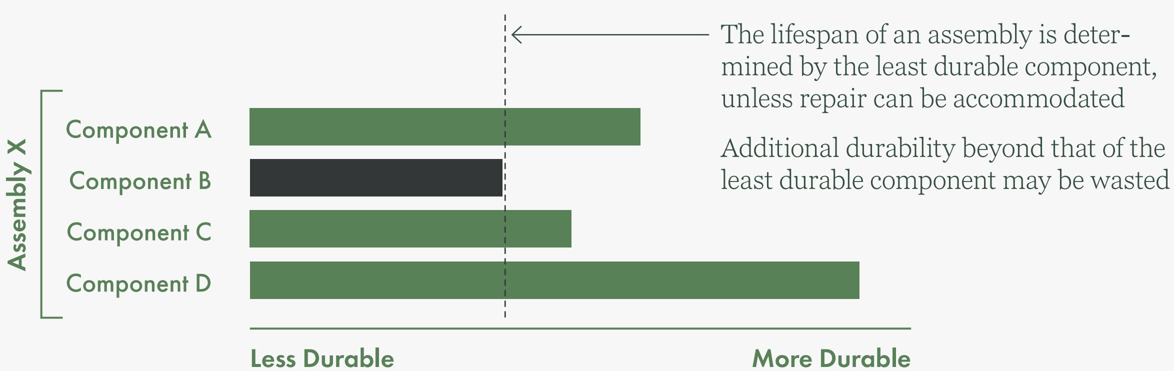
Regenerate by privileging renewable and bio-based materials that are sustainably managed. Choose recycled or recyclable products.

Reduce the amount of material, its embodied carbon environmental impacts; reduce waste by designing for durability, disassembly, recovery, and reuse.

Recycle what cannot be reused or re-purposed.

The shaded area, or the integral of service quality over the service life, illustrates the total amount of *useful service* a product provides before reaching end-of-life—a measure of both its durability and how well it performs over time. In this case, Product 'B' is more durable.





The least durable component of an assembly determines the lifespan of the whole assembly. The greater the difference in durability between components, the greater the wasted durability.

What is durability?

Generally speaking, durability can be thought of as the product of a component's service quality and its service life. Service quality can be broadly defined as an object's functional performance relative to its design expectations, including factors like appearance, reliability, performance, and serviceability.

But there is some nuance to durability. For example, two products may exceed the minimum specified service quality and have the same service life, yet differ in how rapidly they deteriorate. Looking at the chart to the left, the service quality of Product 'B' stays higher, longer, and would therefore be more durable, even though their service lives are identical.

It is also important to consider the durability of building components in aggregate, since many components exist together within assemblies.

But durability is more than just how long something continues to provide useful service. Other dimensions of durability include persistence of service quality, maintainability, functional obsolescence, and ecological restoration.

Technically speaking, durability is defined by the CSA as "the ability of a building or building element to perform its functions to the required level of performance for its design service life in its structure environment under the influence of environmental actions."

Click here to view resources related to the durability of buildings.

Persistence of service quality: The persistence or endurance of service quality refers to how long and how well a particular attribute continues to provide acceptable performance. A material may possess many such attributes. For example, if one attribute is physical appearance, a product that maintains its appearance longer than another would be considered more durable, assuming all other attributes are equal. Another example is the rate of deterioration in the thermal resistance of an insulation material—insulation that better retains its effectiveness over time would be more durable.

Maintainability: Cleaning and maintenance are common requirements for all types of building materials, components, assemblies, and equipment. When there is a significant difference in the time and effort needed to properly maintain one piece of equipment over another, the one requiring less frequent and intensive maintenance is considered more durable or robust, assuming all other attributes are roughly equal.

Functional obsolescence: When a building or component can no longer perform its intended function, it becomes functionally obsolete. This may result from shifts in the real estate market, changes in residents' needs and preferences, or poor initial design that limits re-purposing or adaptive reuse. The durability of a building's economic or social value is a key consideration for property owners, investors, and social housing agencies alike.

Ecological restoration: Materials extracted from nature require time for ecological regeneration, otherwise, natural resources risk becoming depleted. From a sustainability perspective, a material, component, or system can only be considered durable if its service life is reasonably aligned with the time needed for its environmental impacts (from extraction, processing, manufacturing, etc.) to be absorbed by the ecosystem.

Not all parts age alike

When interconnected materials in a building assembly have mismatched service lives, the least durable component often determines the replacement cycle. This leads to the premature removal of more durable elements, wasting part of their potential and increasing recurring embodied carbon. If every material, component, assembly, and system lasted the same amount of time, recurring carbon would be negligible—but deterioration, wear, and tear are unavoidable in reality.

This phenomenon is known as *differential durability*. It describes how the useful service life of building components—structure, envelope, finishes, and services—varies both between elements and within the materials and systems that make them up. The term can also be used at the building scale, comparing the lifespan of the structure to the point of its functional obsolescence.

Evidence shows that, aside from structural elements, nearly all parts of a building require varying levels of maintenance, repair, and replacement throughout their life cycle. The extent of recurring embodied carbon associated with these tasks depends heavily on how well the durability of materials and systems is coordinated—and how accessible they are for ongoing upkeep.

Designing for harmonized durability not only conserves resources, but also supports more resilient, lower-carbon buildings.

The weakest link: Materials are frequently discarded not due to failure, but because they are connected to components that have reached the end of their service life. This is the challenge of differential durability: when components with mismatched lifespans are integrated, the shortest-lived element dictates the replacement cycle, leading to waste and increased recurring embodied carbon.

Recognizing that differential durability is often unavoidable, it becomes essential to design for ease of maintenance and replacement. Components should be accessible and independently replaceable—caulking, for example, can be renewed without disturbing adjacent materials. Similarly with right-to-repair concerns, when replacement parts are unavailable, entire systems may be unnecessarily discarded.

Where possible, durability should be harmonized across assemblies. Cladding and its substructure, brick and its ties, windows and their flashings should all be selected and detailed to age in sync. Shorter-lived elements, such as caulking, can be exceptions—provided they are easy to service.

Deferred maintenance: While maintenance carries a cost, it is significantly lower than the expense and disruption of premature replacements or major repairs. Designing for durability requires careful material selection, thoughtful detailing, and a commitment to life cycle maintenance. Ultimately, it's not just about longevity—it's about minimizing environmental impact and ensuring buildings remain functional, resilient, and resource-efficient over time.

Deferred maintenance only makes matters worse. While upkeep has costs, they're far less than premature replacements and major repairs. Designing for durability means selecting the right materials, resolving details well, and supporting the building through its full life cycle. It's not just about longevity—it's about reducing impact and making buildings that hold up over time.

Carbon

The GWP of greenhouse gas emissions is a critical issue with far-reaching consequences for life on Earth. The building sector is a major contributor, responsible for roughly one-third of global energy use and process-related emissions. A range of environmental impacts—including GWP—can be estimated through a life cycle assessment (LCA), using standardized methodologies. LCAs can be performed for individual products, assemblies, or entire buildings, and are guided by established standards and protocols.

Life cycle assessments 101

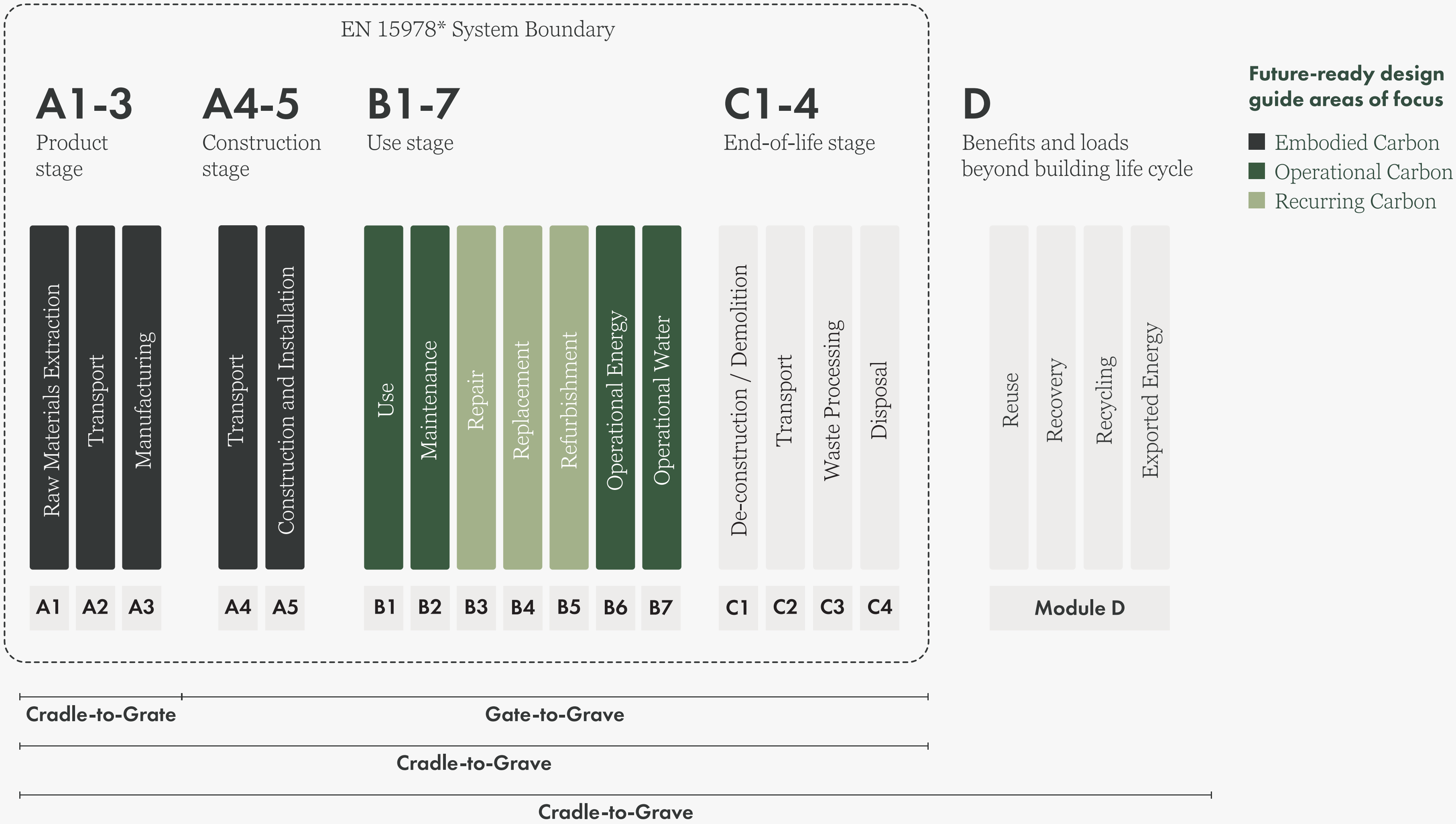
Life Cycle Assessment (LCA) is the methodology of evaluating the environmental impacts of a material, product, component, assembly, system or building, from the moment of extraction of raw materials to transportation, processing, manufacturing, use, recyclability, and disposal.

Environmental Product Declaration (EPD) is a standardized, third-party verified document based on a life cycle assessment that transparently communicates the environmental impact of a product or material throughout its entire life cycle, from raw material extraction to disposal.

Life Cycle Inventory (LCI) is a list of input and output flows for a particular process. The flows are resource use, such as materials, energy, and water, as well as emissions to air, land, and water.

Life Cycle Impact Assessment (LCI) is the phase of LCA aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. These results may estimate "mid-point" impacts, such as GWP, or "end-point" impacts, such as damage to human health.

Study period is the time frame over which an LCA is conducted. For materials and most products, this period corresponds to their entire useful service life. For a building, it is difficult to forecast its useful service life and so it is commonly accepted that a service cycle of 60 years should be used as the study period, after which it is assumed a major makeover of the building will be required, thus marking the beginning of its next service cycle. Most buildings will endure over several service cycles, because it is unrealistic to make reliable forecasts over the entire service life of the building.



* CEN (2012b) NBN EN 15978: Sustainability of construction works - assessment of environmental performance of buildings - calculation method. European Committee for Standardization, Brussels, Belgium.

LCA assessment system boundary

LCAs are a complex process involving an extensive gathering of EPDs and physical building quantities, combined with forecasts for the Use stage (modules B1-B7) and the End-of-Life stage (C1-C4). Conventional assumptions for the Use stage can vary significantly from actual real world operation and maintenance. The End-of-Life stage is typically too far in the future to make accurate predictions, and statistically significant historical data are currently not available. When a study period of less than the service life of a building is selected, modules C1-C4 are not considered.

Stages of an LCA

After decades of refinement, LCA standards now define clear stages for evaluating buildings. Two key concepts in LCAs are the *system boundary* and the *functional unit.*

System boundary: This sets the scope of what's being assessed. Currently, only Stages A (product and construction), B (use), and C (end of life) are included—though Stage D, which accounts for reuse, recovery, and recycling, is recognized as essential to circularity.

Functional unit: For buildings, life cycle impacts are often expressed per unit of gross floor area—for example, kilograms of carbon dioxide equivalent per square metre (kg CO_2e/m^2)—to allow comparisons. In housing projects, impacts per bedroom (kg CO_2e/bedroom) may be more appropriate. In many cases, multiple functional units are reported to assess design efficiency and functional utility across different proposals. These units provide the basis for comparing relative climate impact per relevant attribute of a building.

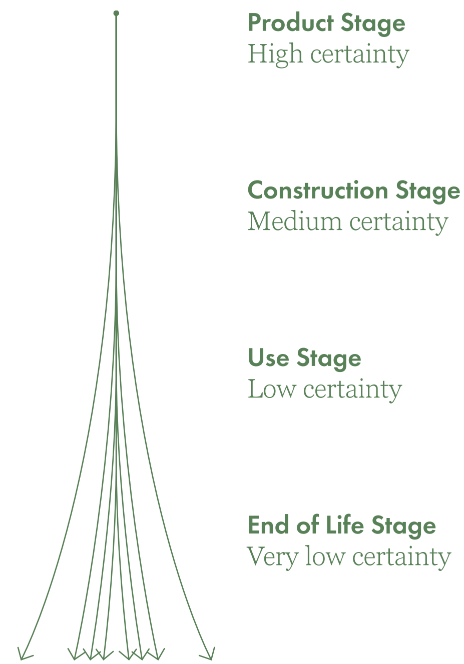
How to read an LCA (without over reading it)

It is important to recognize that in conducting LCAs—even when practitioner guidelines and protocols are carefully followed—the absolute accuracy of impact assessments diminishes as calculations move from the product stage to the construction stage, and further into the use and end-of-life stages.

This decline in precision reflects the long service life of buildings, which often extends well beyond the foreseeable future, introducing significant variability in factors such as building use and occupancy, deferred maintenance, churn rates, retrofit cycles, and the carbon intensity of future energy and materials. Uncertainty compounds on uncertainty, making any long-term prediction subject to high potential for high divergence.

As a result, LCAs of different design scenarios for a proposed building should be interpreted as comparative indicators rather than absolute metrics. Percentage differences between alternatives typically provide a more reliable basis for comparison, as the absolute embodied carbon values of each option are subject to an unknown and potentially significant degree of uncertainty.

Understanding these limitations can help designers and decision-makers avoid false precision and instead focus on directional insights—prioritizing low-carbon strategies that consistently outperform others across a range of assumptions.



> LCAs are effective and best used for comparative analysis. Given the very long lifespans of buildings, absolute metrics for later stages can be divergent.

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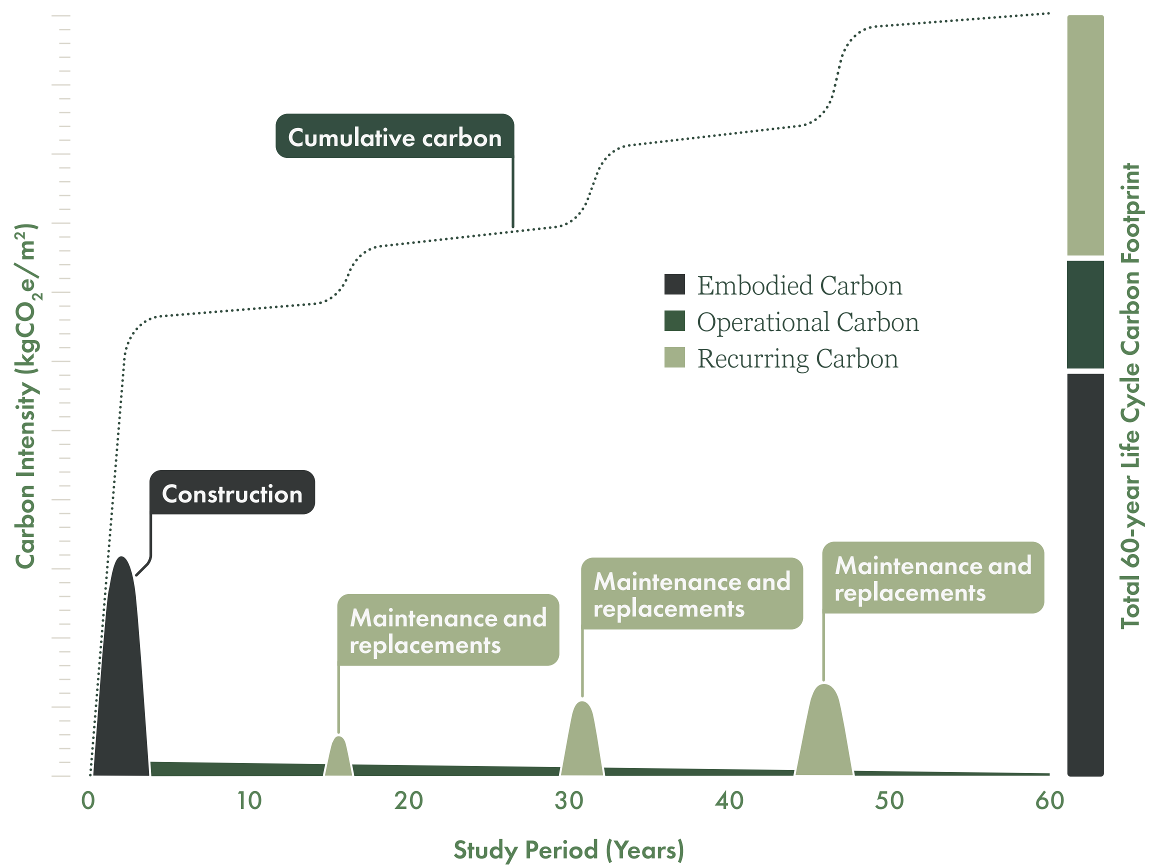
Recurring carbon from maintenance, replacement, and retrofit operations and is the next largest source of carbon emissions after embodied carbon.

Whole Life Carbon (WLC) of buildings

Unlike individual materials, buildings require inputs of energy and water over their entire life cycle, which typically produce operational carbon emissions. Also, because buildings comprise many materials, components, assemblies, equipment, fixtures and systems, as these age, deteriorate and breakdown their maintenance, repair and replacement incur recurring carbon emissions.

The embodied, operational and recurring carbon comprise the WLC of the building for a chosen study period. It has been generally accepted that a 60-year LCA study period will capture most, if not all, of the carbon emissions associated with a service cycle—the period of time after which major replacements, retrofits, and refurbishments become necessary to conserve the service quality of the building asset.

Designing for low carbon without considering operational and recurring carbon potentially risks constructing buildings that start out as having low embodied carbon but eventually incur a higher carbon footprint as the building ages. It is important to balance a building's durability and metabolism with its upfront carbon footprint. Only by assessing a reasonable service cycle that accounts for operation, maintenance, repairs, retrofits and replacements can an environmentally responsible WLC footprint be achieved.



Operational carbon is anticipated to decline over time as the grid is decarbonized. Maintenance and replacements occur with increasing recurring carbon impacts as the building ages. Upfront carbon accounts for over half of the 60-year footprint, followed by recurring carbon. Designing for durability, serviceability, and adaptability can significantly reduce recurring carbon—especially beyond year 60, when the building enters a new service cycle.

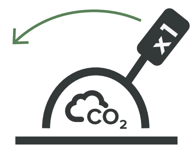
WLC profiles: recipes for lower carbon

Detailed carbon accounting can seem overwhelming. But thankfully, numerous studies have indicated that there are certain recipes for construction and materials that result in a narrowed range of embodied carbon intensity.

For example, analyses have shown that the number of underground parking levels strongly influence the embodied carbon of MURBs made from reinforced concrete. So do other moves, like step-backs, which require exceedingly large and carbon intensive transfer slabs to accomplish.

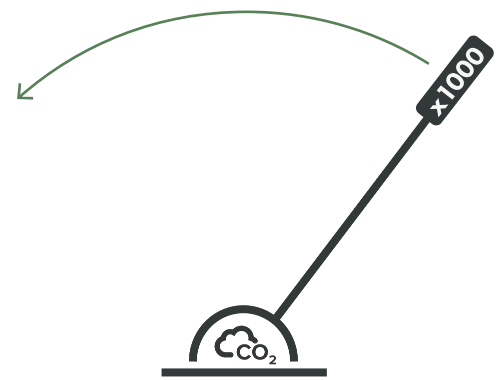
It is important to recognize that LCAs can be simplified by only assessing major contributors to carbon footprint. Accounting for the carbon in MEP systems, for example, does not provide meaningful efficiencies relative to other, order-of-magnitude larger carbon sources.

> Every building system, from structure to MEP, contributes carbon; but some systems contribute far more than others. Focus on the big ticket items first.



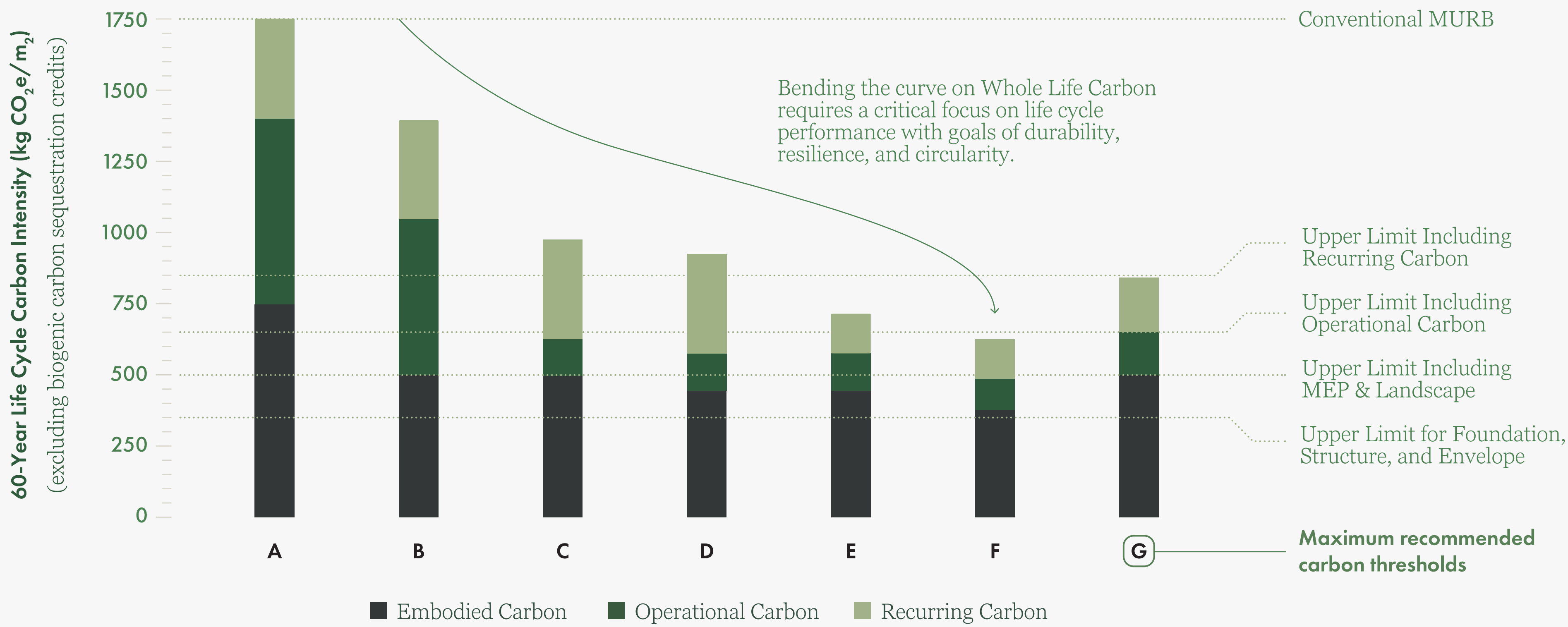
Small Lever
Electrical, plumbing, interior finishes, furniture, interior partitions, fasteners, minor fixtures, etc.

- Very complex to measure
- Hard to implement
- Very small impact, relatively



Big Lever
Structural system, underground parking, step-backs, enclosure, heat pump refrigerants, serviceability and durability, energy source, etc.

- Easier to measure
- Easier to implement
- Very large impact



A **Conventional concrete MURB**
Structure: reinforced concrete, shear walls
Parking: multi-level underground
Enclosure: window-wall
Energy: natural gas space and water heating
Air Handling: 2-pipe fan coils
ERV: No
Durability / Serviceability: poor

B **Reduced underground parking MURB**
Structure: reinforced concrete, shear walls
Parking: minimal underground
Enclosure: window-wall
Energy: natural gas space and water heating
Air Handling: 2-pipe fan coils
ERV: No
Durability / Serviceability: poor

C **Concrete column and capital MURB**
Structure: reinforced concrete, column & capital
Parking: minimal underground
Enclosure: high performance
Energy: ground source heat pump
Air Handling: 4-pipe fan coils
ERV: Yes
Durability / Serviceability: poor

D **Mass timber MURB**
Structure: mass timber
Parking: minimal underground
Enclosure: high performance
Energy: ground source heat pump
Air Handling: 4-pipe fan coils
ERV: Yes
Durability / Serviceability: poor

E **Mass timber MURB**
Structure: mass timber
Parking: minimal underground
Enclosure: high performance
Energy: ground source heat pump
Air Handling: 4-pipe fan coils
ERV: Yes
Durability / Serviceability: good

F **Wood frame MURB**
Structure: conventional stick frame
Parking: minimal underground
Enclosure: high performance
Energy: ground source heat pump
Air Handling: 4-pipe fan coils
ERV: Yes
Durability / Serviceability: good

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Click here to view resources on whole life carbon assessment.

Carbon and material choices

The embodied carbon in building materials varies significantly, both within and between material types. Relying on industry averages for materials such as wood, steel, or concrete can be misleading. It is critical to select materials that have valid EPDs in order to develop meaningful LCAs. In many instances, EPDs for certain products are not available, and so comparative means must be employed to reasonably estimate their embodied carbon.

Understanding parts of a whole

For components like windows and assemblies such as exterior walls, it is also important to determine the relative contributions to the embodied carbon by each of the constituent parts.

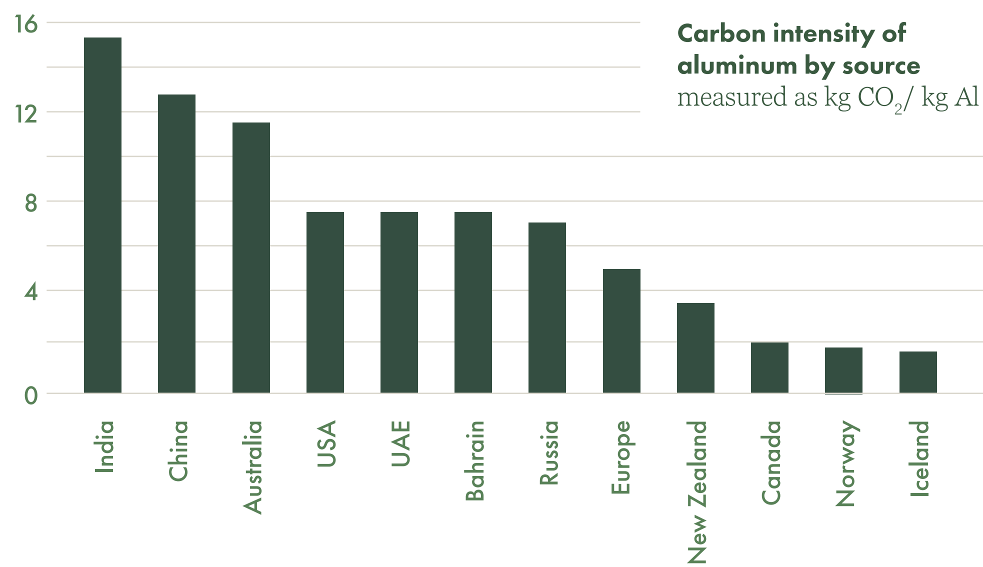
For example, windows typically consist of a frame and a sealed glazing unit, also referred to as an insulating glazing unit (IGU). The frame material will have a range of embodied carbon depending on the material chosen and how it is processed. The IGU itself consists of glass layers, any low-e coatings, the edge seal, and, in some cases, tempered glass. In general, the glass accounts for 75% or more of the IGU's embodied carbon. The contribution of the window frame compared to the IGU varies considerably with the frame material.

Carbon and material choices

The chart below reinforces the importance of sourcing materials responsibly. Low-cost imported materials and equipment tend to correspond with higher embodied carbon contents and greater environmental impacts.

Specifications should be written to prevent the substitution of materials with EPDs by those without. Performance criteria should be established for materials in the specifications—including embodied carbon, vapour permeance, and thermal resistance—and any proposed substitutions should be required to demonstrate equivalent performance.

Not all materials are made equally: depending on its source, the carbon intensity of aluminum can vary by as much as 8x.



Carbon intensity of aluminum by source
measured as kg CO_2/ kg Al

Major contributors to embodied carbon in buildings

Building	**Foundation**	piles, caissons levels of below-grade parking	Limiting the scale of foundations by reducing or eliminating underground parking yields a significant reduction.
	Structure	shear walls *vs* post & beam wood *vs* concrete & steel	Up to 6 storeys, there are many low-carbon choices. Taller buildings have fewer options, but the optimization of structures and avoiding shear walls can yield significant reductions.
	Envelope	window-to-wall ratio (WWR) form factor (envelope surface to floor area ratio)	Glass is carbon intense and reducing WWR can yield reductions. Minimizing surface area of building envelopes also yields reductions in carbon, as well as resource extraction overall.
Assemblies	**Roofs**	roof structure insulation bitumen membranes, cladding	Green roofs built with plastic and bituminous materials are highly carbon intensive. Where possible, choose low carbon, long-life materials that are reusable and recyclable.
	Exterior walls	backup structure insulation cladding & attachments	Foamed plastics are popular yet highly carbon intensive compared to other insulation materials. When allowable, bio-based insulation materials are ideal. Cladding materials should be easily serviceable, durable, and reusable or recyclable.
	Floors-on-grade	floor structure insulation floor finishes	Choice and quantities of materials are vital. Low-carbon, durable finishes that are easily restorable—such as terrazzo, hardwood, and linoleum—are ideal.
Components	**Windows**	frames/mullions glazing	A balance between durability, thermal efficiency, and embodied carbon is critical. Punched windows offer better life cycle performance than window walls and curtain walls.
	Equipment	domestic *vs* imported warranty & right to repair	Check the right-to-repair policies of manufacturers to ensure availability of parts over the life cycle of the equipment.
	MEP	metals *vs* plastics refrigerants domestic vs imported	Refrigerant leaks can account for much of a building's whole life carbon emissions, since refrigerants can have GWPs far higher than CO_2. Choose low GWP refrigerants for heat pumps and chillers.
Materials	**Concrete**	low carbon concrete optimize rebar	Concrete embodied carbon can be reduced by up to 30% through the use of supplementary cementitious materials (SCMs) and optimizing the deployment of reinforcing steel.
	Steel	domestic *vs* imported recycled *vs* virgin iron ore Electric Arc Furnace (EAF) *vs* Blast Oxygen Furnace (BOF)	Canadian steel has amongst the lowest embodied carbon content in the world. Our steel is made using EAFs and recycled steel scraps, a process 4x less intensive than BOF processes.
	Wood	domestic *vs* imported engineered *vs* solid wood certification	While renewable materials are typically low carbon, it is important to ensure that these resources are managed sustainably with minimal impacts on biodiversity and environmental degradation.

Major contributors to embodied carbon in sites

Landscape

Hard surfaces

- asphalt
- chip seal
- concrete
- stabilized gravel
- stone or pavers

Reusable hard surfaces, like stone or pavers, are preferred over asphalt and concrete. Chip seal is a lower-carbon alternative to asphalt, with higher albedo and permeability. Stabilized gravel and permeable pavers promote better stormwater management.

Stormwater

- modular suspended pavement
- grey *vs* green infrastructure
- water features

Grey infrastructure such as catchbasins, culverts, and reinforced concrete pipes can be replaced with green infrastructure such as retention ponds, bioswales, wetlands, and rain gardens. Green infrastructure is cost effective, resilient, and low carbon; it can also function as a water feature.

Site engineering

- retaining walls
- site circulation & accessibility
- water features
- slope stabilization
- sub-grade preparation

Stone-filled gabions can be a low-carbon alternative to reinforced concrete retaining walls. Use green stormwater infrastructure as a water feature. Consider alternatives to concrete for sidewalks, stairs, and ramps. Shoring, piling, and imported fill is high carbon. Green alternatives include vegetated geogrids, terraced planting, gabion mattresses, and erosion control blankets.

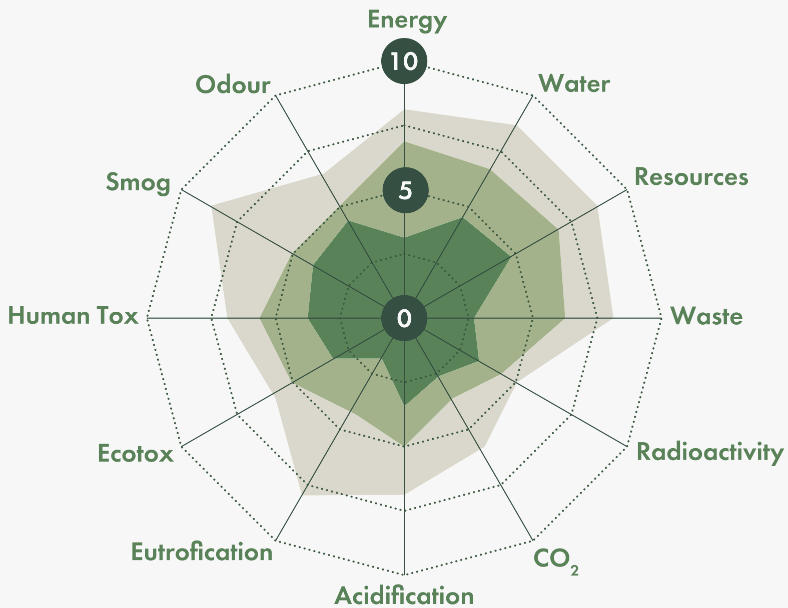
Practical durability considerations

In MURBs, there are also a number of miscellaneous but important considerations that are often overlooked. For example, the choice of floor and wall finishes in hallways and corridors is important, as these areas must endure significant traffic and wear. At-grade exterior finishes should be robust and resistant to abrasion and impact to help avoid premature repairs and replacements. High-quality, rugged elevators may be more expensive initially, but evidence shows they incur the lowest life cycle costs and minimize disruptions due to service outages.

Even simple protocols—such as the annual exercising of plumbing valves—help keep systems functional and avoid the need to shut down plumbing to replace seized valves. Durability is primarily a matter of material selection, but it also depends on good design and proper operations and maintenance.

Sustainability beyond carbon

While GHG and carbon emissions are a critical concern, it is also important not to neglect other environmental impacts when choosing the materiality of buildings. Ultimately, all building materials are extracted from natural systems with limited rates of regeneration. These rates depend on ecological conditions that have existed for millennia, well before industrialization. Other environmental impacts, besides carbon, affect these conditions for regeneration and pose a threat to long-term sustainability.



An eco-profile can be constructed by normalizing environmental impacts of interest to an appropriate scale (here, 1-10) and then plotting them on a radar diagram. In this example, the environmental impacts have been obtained from a standard LCA, but other impacts such as resource depletion, environmental degradation and reduction in biodiversity may also be included.

- *Conventional:* not ecologically sensitive
- *Green:* improved practice
- *Sustainable:* Ecological footprint matches biocapacity

Ecological footprints 101

Ecological footprint is a measure of the pressure for resources each person, group, or human activity places on the planet.

Global hectare (gha) is a unit of measurement used to represent the biologically productive area—land or water—needed to provide the resources a population or activity consumes and to absorb their waste. In 2014, Canada's Ecological Footprint measure was 8.28, meaning Canadians required 8.28 gha per person in order to meet their demand for resources and to absorb ecological waste.

Biocapacity is the capacity of ecosystems to regenerate what people demand from them—including food, fiber, timber, and carbon absorption. In short, while ecological footprint is our *demand* on nature, biocapcity is *supply* from nature. It is also measured in global hectares (gha).

Globally, humans are using resources faster than the earth is capable of regenerating them. On average, the resources used in one year take 1.5 years to regenerate. Canada's biocapacity in 2014 was 14.6 gha per person, meaning our biocapacity (supply) still exceeded our ecological footprint (demand). Unfortunately, the gap has been narrowing each year, meaning Canadians are getting closer to consuming natural resources faster than our environment is able to regenerate them.

Why circularity?

Circularity isn't just a fringe concept—it is literally the basis of all mass and energy flows in the physical universe (which includes our planet). In natural ecosystems, where all of our raw resources come from, materials are re-used continuously in circular cycles; nothing goes to waste. Circular building is an attempt to harmonize our built environment with these natural cycles.

Our current, linear economy starts with extraction (mining or harvesting) and ends with disposal (landfill). The AEC sector generates enormous quantities of waste because its constituent materials are not reused, recycled, or regenerated. Instead, we dump megatonnes of disused building waste, comprising over one-third of all landfill waste by mass. This linear flow short circuits the circular order of the planet, posing an unsustainable ecological footprint on all resources.

Linear: A one-way process that starts with extraction and ends with disposal, often without meaningful reuse, repair, or recycling.

Circular: The intentional cycling of materials, components, assemblies, equipment, fixtures, and furnishings to extend their usefulness and service life—reducing or eliminating the need to extract new resources from nature.

Cyclical: A repeating process that unfolds over a set time frame. Cyclical processes can be either linear or circular—think of replacing a roof membrane (linear) versus the daily rhythm of the sun and seasons (circular).

Cycle: Also called a technical cycle, a cycle describes the lifespan of a material or system: the stretch from first use to eventual replacement, disassembly, reuse, recycling, or disposal.

In natural systems, cycles and circularity are inseparable. Trees, for instance, grow in seasonal cycles, each year leaving behind a growth ring. When they die, they break down and enrich the soil, fueling new life—a cycle nested within a larger circular pattern of renewal.

Reusing vs recycling: It is generally acknowledged that reuse has a lower carbon footprint than recycling, but it is important to recognize that recycling still has a much lower footprint than that of virgin materials which require extraction, processing, and/or manufacturing.

Much of recycling is associated with downcycling, or the conversion of waste outputs into new, lower performance materials, such as the production of cellulose insulation. It is important to note that downcycling on its own is not strictly circular since the material is degraded each cycle, eventually becoming waste, but it is still highly preferred to virgin materials.

Reuse

Employing waste—like demolition debris—for its original purpose or adapting it for a new one, often with some degree of cleaning, refinishing, or refurbishing to restore its utility.

Recycle

Processing waste to create something new. Typically requires re-manufacturing, which degrades performance each time it is recycled. Therefore, recycling is not strictly circular because outputs may eventually degrade too much to be recycled again.

Upcycle

A design-driven process that transforms waste into products of equal or greater value, enhancing their quality, function, or aesthetic beyond their original purpose.

Downcycle

The breaking down of waste into constituent materials and re-manufacturing them into new products of lower performance or value than the original.

Thinking beyond the present: Circularity isn't where sustainable design begins, but it may be where it needs to end up. To understand its role, it's helpful to step back and consider the bigger picture of sustainable architecture. It's not necessary to list every principle, but at the core, buildings should tread lightly on the environment, use resources sparingly, and offer spaces that are durable, flexible, and comfortable—spaces that can keep pace with changing needs over time.

The 1987 Brundtland report, *Our Common Future*, captured the essence of sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." That idea of intergenerational equity remains at the heart of sustainable architecture. It also sharpens the case for circularity: we must design buildings that can be re-imagined and reshaped by those who come after us, without draining ecosystems or pushing past the limits of what the planet can sustain.

Circularity isn't just about materials and fixtures. It impacts the way buildings are lived in, adapted, and eventually transformed across their entire service lives.

Linear buildings: These are constructed with single-use materials, components, assemblies, equipment, and fixtures that exhibit a high degree of differential durability. It supports a narrow range of uses and a fixed occupancy pattern, making it difficult for inhabitants to adapt the space as needs and desires evolve. Throughout its operation and maintenance, it demands continuous inputs of non-renewable energy and resources. At the end of its service life, it is demolished, generating a waste stream that cannot be meaningfully reused, re-purposed, recycled, or recovered.

Entropy is maximized; intergenerational equity (for the future) is minimized.

Circular buildings: These are assembled from renewable, reused, re-purposed, recycled, and recyclable materials, components, assemblies, equipment, and fixtures, all selected to align with harmonized durability cycles. It is designed to support a broad range of uses and variable occupancy, allowing inhabitants to easily rearrange and adapt spaces over time. Its operation and maintenance rely primarily on renewable energy and resources. When its service life ends, it is carefully disassembled, with most of its materials returned to the circular economy for future use.

Entropy is minimized; intergenerational equity (for the future) is maximized.

In a circular economy, a product is preserved as much as possible, retaining as much value as possible. The design of buildings to retain their original attributes with minimal renovations and replacements is a form of persistence.

In the same way there are helpful heuristics and data to guide low carbon design, there should be a reliable means to gauge circularity. At present, this is still in development.

Circularity metrics: It is important to develop metrics and indicators of circularity potential to: 1) inform product design, 2) guide building design—eventually influencing codes and standards—and, 3) estimate the feasibility of deconstruction and material recovery from the existing building stock.

Circularity in the buildings sector is still a nascent movement, and many conventional indicators await evidence-based validation. In time, individual indicators could be combined into composite ratings that more effectively inform design.

Unlike physical sciences, the concept of circularity has not yet matured into a field with well-established metrics. As a result, few reliable tools are currently available to guide material selection. However, some early indicators of circularity can already offer meaningful direction to designers.

Cycle Factor (CF)

The number of times a product may be used before it is considered unrecoverable and must be recycled or disposed of.

Recovery Potential (RP)

A measure of the proportion of an installed product or material that can be recovered for less embodied carbon and labour than the original. This measure takes into account factors such as: suitability of reuse, required remediation work, recycling, biodegradation, and disposal.

Degree of Disassembly (DD)

The possible extent of disassembly for a building as a whole (composite potential) or a constituent component or assembly. DD also takes into account recovery potential.

Reusability Factor (RF)

A measure of how reusable a product or material is in terms of the degree of processing required to render it usable.

Degree of Recyclability (DR)

A measure of the extent to which a material can be recycled. Some material, like adhesives, cannot be recycled at all; others, like asphalt, can be recycled but require being mixed-in with virgin feedstock. Few materials are fully recyclable, also known as "closed-loop," where no value or quality is lost during recycling: such as glass, aluminum, and copper. Even steel sees some property loss during recycling due to impurities that are inadvertently introduced during remelting.

> An ideal material would have a high cycle factor, be fully recoverable, easily disassembled, fully reusable, and fully recyclable for less embodied carbon inputs than the original. Ideal components, assemblies, equipment, and fixtures would be made out of ideal materials.

Economic circularity = C_e (usually <1)

$$C_e = \frac{\text{dollar value of recirculated components}}{\text{dollar value of entire original product}}$$

Embodied carbon circularity = C_e (usually <1)

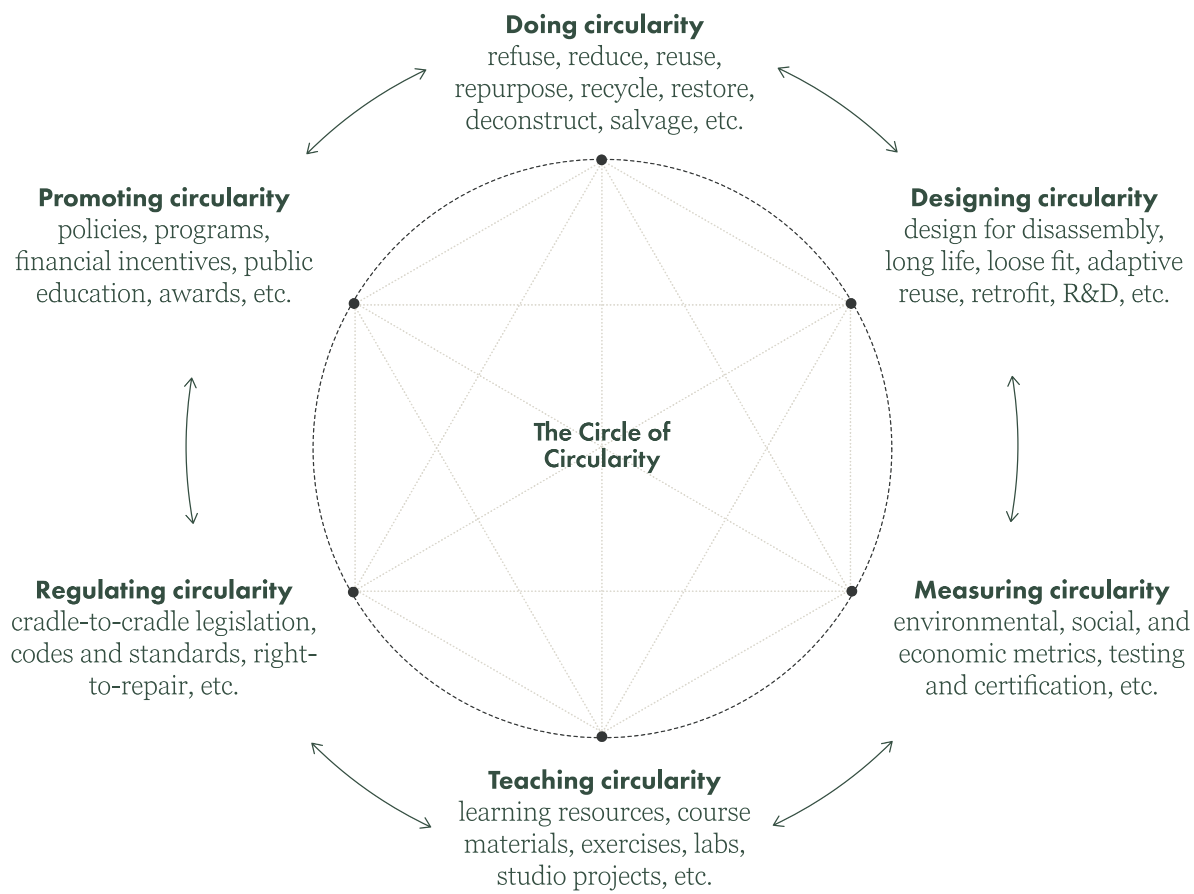
$$C_c = \frac{\text{embodied carbon of recirculated components}}{\text{embodied carbon of entire original product}}$$

Click here to view resources for circularity in building design.

The role of circularity in design: Circularity is not the most critical consideration at the early stages of design; rather, it is a desirable attribute after everything possible has been done to minimize materiality, maximize utilization efficiency, and extend useful service life. This hierarchy remains the same regardless of the degree of circularity of the constituent building materials, and it speaks to the need for conservation and the best possible use of our planet's finite resources.

Circularity is both a means to an end, and an end in itself, when viewed through the life cycle perspective of buildings. By using materials, components, assemblies, equipment, and fixtures with high circularity potential, the end-of-life circularity of a building is enhanced. However, it is important to recognize that this circularity must operate within a sustainable ecological footprint. A perfectly circular material can still become completely depleted; therefore, circularity has limits and must be closely allied with non-extractive architecture and low-carbon building design.

Circular design means minimizing materiality (sufficiency), maximizing utilization efficiency (smart design), and extending useful service life (durability).



The future of circularity - The transition towards a circular economy is happening much slower than hoped, but it is still moving in the right direction. Architects are primarily involved in designing circularity but should also attempt to network with the other stakeholders in order to advance every aspect of circularity.

Material strategies: making the right choices

We get it, making responsible material choices can be a difficult exercise. There are many factors that have to be reconciled. Thankfully, a materiality assessment framework can be a helpful aid to make the task easier and more consistent.

Keep in mind that technical performance specifications become more critical and complex as building elements become increasingly composite: from material, to component, to assembly, to system. The ease of sorting out the provenance and suitability of constituent materials for composite pieces also becomes more challenging and tends to rely on industry standards and product certifications. The checklist on the right is a basic evaluation framework that can be easily implemented and evolve with use.

First, a building material or product must be fit for its intended purpose. Only materials that satisfy this requirement should be considered.

Consider multifunctional materials to help reduce consumption. For example, an air barrier that is also a weather resistive barrier.

Evaluation of materials, components, and assemblies

Durability

□ service life	□ differential durability	□ maintenance	□ replacement

Carbon

□ carbon intensity	□ biogenic carbon	□ local or imported	□ recycling/disposal

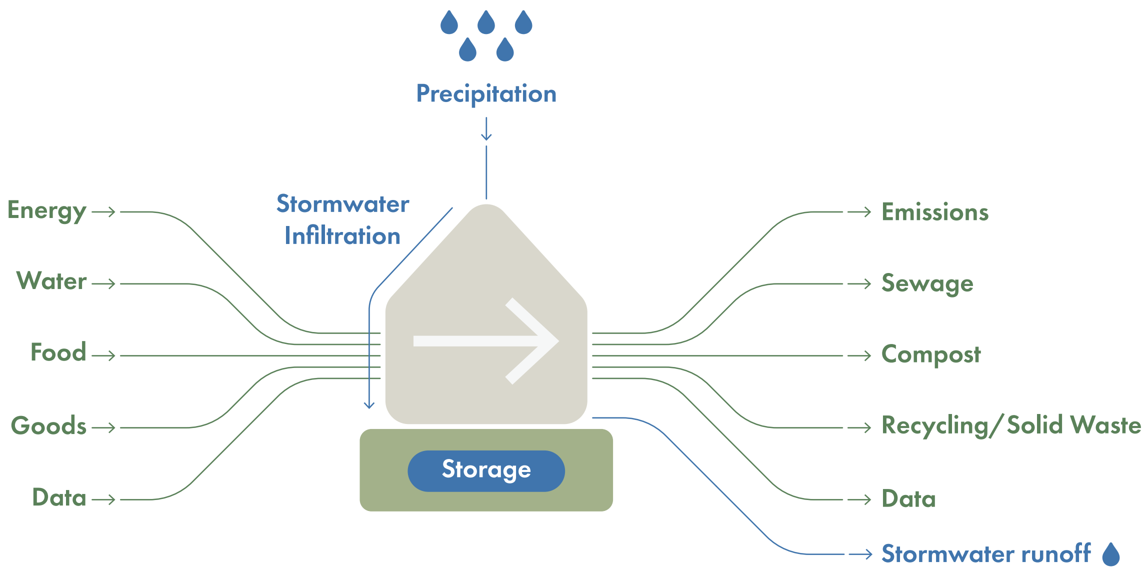
Ecological footprint

□ resource depletion	□ reduced biodiversity	□ ecosystem degradation	□ toxicity

Circularity

□ reusability	□ recyclability	□ right-to-repair	□ design for disassembly

Metabolism



What is metabolism?

Typically, we think of "metabolism" as a series of reactions that occur within the cells of living organisms to sustain life. These are the processes that convert food into energy and break down or build up materials in the body. In architecture and buildings, "metabolism" is used in an analogous way to describe how buildings and their inhabitants consume energy, water, food, goods, and data, and also how the precipitation that falls on the building and its site are intercepted and processed.

In the previous sections on morphology and materiality, the focus was largely on embodied and recurring carbon for the whole life of the building. With metabolism, operational carbon becomes the major player, since we are now focused on mass and energy flows during building occupation.

Mass and energy flows: Buildings can be thought of as prosthetic devices that shelter humans from external environments, extending our ability to work productively and live comfortably and safely. It's no surprise, then, that buildings tend to mirror human metabolisms involving certain mass and energy flows.

Some mass and energy flows are purely related to a building's occupants—like food and potable water. These are subsequently metabolized by the occupants and converted to compost, sewage, and other waste outputs.

Other mass and energy flows are directly related to building operations, including energy used for heating, cooling, lighting, equipment, and appliances. Mass flows involve materials that flow in and out of the building, and can include cleaning products, paint, furniture, carpeting—all forms of recurring carbon—and discarded outputs such as garbage and recycling.

Some energy flows also appear as mass flows, especially for heating and cooling. In the case of Toronto, many buildings in the downtown core receive heating and cooling in the form of steam from a centralized district heating system or chilled water from the Deep Lake Water Cooling system (DLWC). These inputs dispense of their heating or cooling work within the building, and are returned as building outputs back to central infrastructure for reconditioning.

Buildings also include their sites. Today, buildings are required to manage stormwater flows to help reduce flooding and pollution of local water bodies. In these cases, the metabolic action can be seen as a filtering or buffering of stormwater—a symbiotic function that benefits the surroundings and, ultimately, the subject building as well.

The design of a building's metabolism is ultimately driven by the building's demands for resources, but also the needs and behaviours of its users.

Passive and active systems

With the exception of the simplest of enclosures, practically all buildings consist of both passive and active systems. Ideally, these systems complement each other to satisfy the needs of inhabitants and provide a sufficient level of environmental control.

Let's contextualize what these systems mean and their role in the metabolism of buildings:

Passive systems: These features moderate the environment for the safety, health, and well-being of occupants with minimal energy inputs. These systems should minimize embodied carbon by eliminating equipment, and minimize operational and recurring carbon by their simplicity and lower dependence on maintenance.

Active systems: These features primarily supplement passive systems in order to provide a desired level of indoor environmental control, usually through means which convert energy from one form to another. These systems consume resources and produce operational carbon, so they should be designed to be highly efficient and, ideally, use clean, renewable electricity.

The limit of active systems: The resource use intensity of active systems is usually outside the control of the architect or designer. Of course, significant savings can be made by specifying efficient equipment and low-carbon energy sources, like electricity, but occupant behaviour will largely drive their use. Architects and designers exert the most life cycle impact through the massing, geometry, and orientation of the building, and especially their design of the enclosure.

Passive systems as an armature: Passive systems can be thought of as the armature that enables both active systems and occupant behaviour. It is much easier to modify, adjust, and replace active systems than the building armature, which includes its structures, envelope, and fenestration.

A building's passive physical attributes, not its active systems or occupancy, determine the upper boundary of its environmental performance potential. Passive systems establish the armature of the building within which all active systems are nested. The relative permanence of passive elements suggests their performance should approach best in class. Only then will the ability of active systems to enhance performance not be compromised by an inferior armature.

Building mass and energy flows: critical considerations

	Mass and energy flows	Critical considerations
Passive	**Heat** **Air** **Moisture** **Solar radiation**	Influenced by the design of enclosures and their control layers for the management of heat, air, moisture and solar radiation flows. Final construction quality can heavily impact actual performance; prioritizing constructability can reduce construction errors. Solar heat gains can be managed by shading devices, planting, and glazing properties (U-value and SHGC).
Passive	**Stormwater**	Controlled by infiltration, detention, and storage measures. Landscape features, such as permeable pavers, ponds, and bioswales can be cost-effective and attractive. Hidden grey infrastructure, like cisterns and pipes, are common and can be space efficient.
Active	**Potable water**	Influenced by occupant behaviour and efficiency of plumbing fixtures. Sewage outputs correspond to water consumption.
Active	**Space heating** **Space cooling** **Mechanical ventilation**	Influenced by passive measures (above), occupant behaviour, and equipment efficiencies. Ventilation energy corresponds to the number of occupants, air handling equipment efficiency, and ERV efficiency.
Active	**Domestic water heating**	Influenced by occupant usage, efficiency of plumbing fixtures, and energy conversion efficiency of water heating equipment. Drainwater heat recovery can play a role in reducing losses.
Active	**Lighting**	Influenced by daylighting, occupant activities, and fixture energy efficiency. Fixtures with integrated LEDs, which are common, have high waste potential if the LEDs are not easily serviceable.
Active	**Plug loads**	Influenced by occupant behaviour and efficiency of appliances, equipment, and devices.
Active	**Fire safety (alarms, sprinklers)** **Vertical transportation** **Building automation systems and controls**	These are essential life safety devices. Their durability and reliability are more critical than their mass and energy flows. Emergency power for these systems is highly recommended if it is not already required.
Active	**Food** **Furniture** **Other consumer goods**	Influenced by occupant needs and preferences, but also interior design. Furniture can be more adaptable than millwork, minimizing wasteful renovations and recurring carbon; however, millwork can also be more durable than furniture.
Active	**Compost** **Recycling** **Solid waste**	Influenced by user behaviour; convenient access by occupants to composting, recycling, and solid waste facilities is critical to successful resource recovery.
Active	**Communications** **Transportation**	Accessibility/proximity are key considerations.

Human behaviour is highly variable. Design for positive feedback loops that can influence behaviour; for example, sub-metering individual units can reduce energy use.

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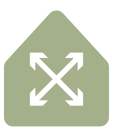
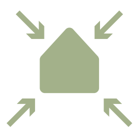
The building envelope is the most important passive system because it is the primary environmental mediator. It proves shelter and must effectively resist numerous external phenomena. In our climate, it must also be thermally efficient across a wide range of temperatures, durable against weather and high hygric pressures, and resilient over the long life cycle of buildings.



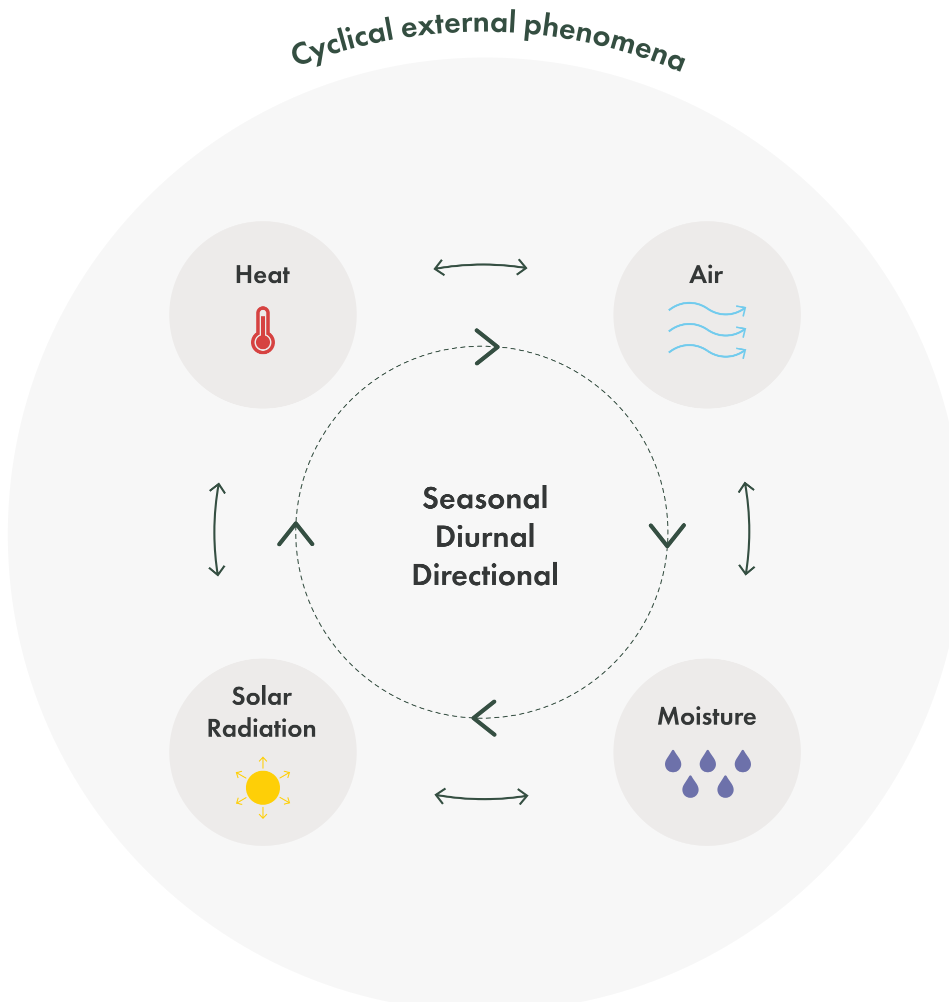
Internal phenomena

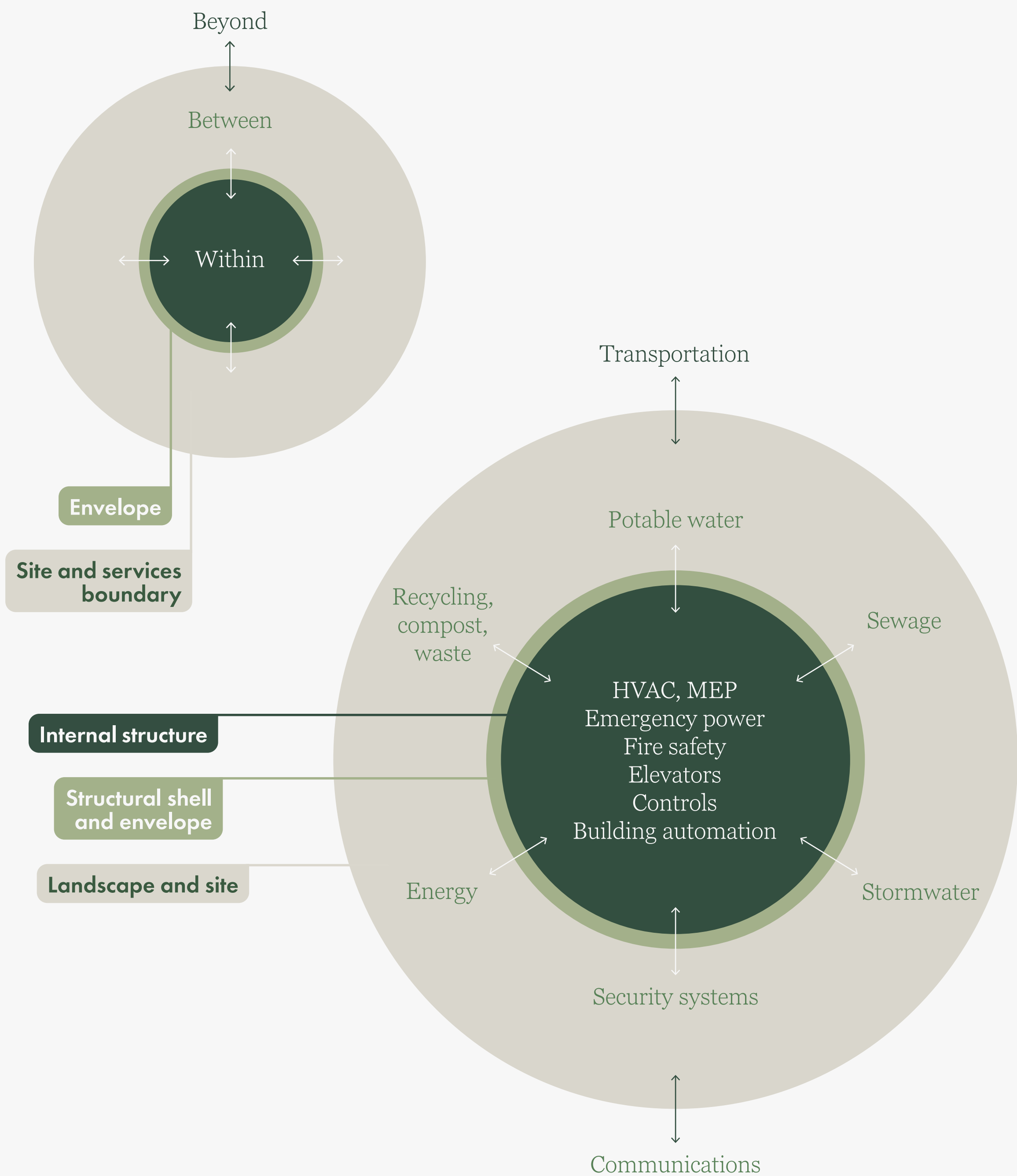
- Occupancy (wear and tear)
- Impacts and vibrations
- Stack effect (air pressure)
- Moisture and humidity
- Solvents and cleaners
- Biological agents (mold, mildew, insects, rodents)



External phenomena

- Gravity
- Climate and extreme weather
- Air pollution
- Abrasion and UV degradation
- Biological agents (mold, mildew, insects, rodents)
- Groundwater, flooding
- Seismic activity
- Noise and vibration





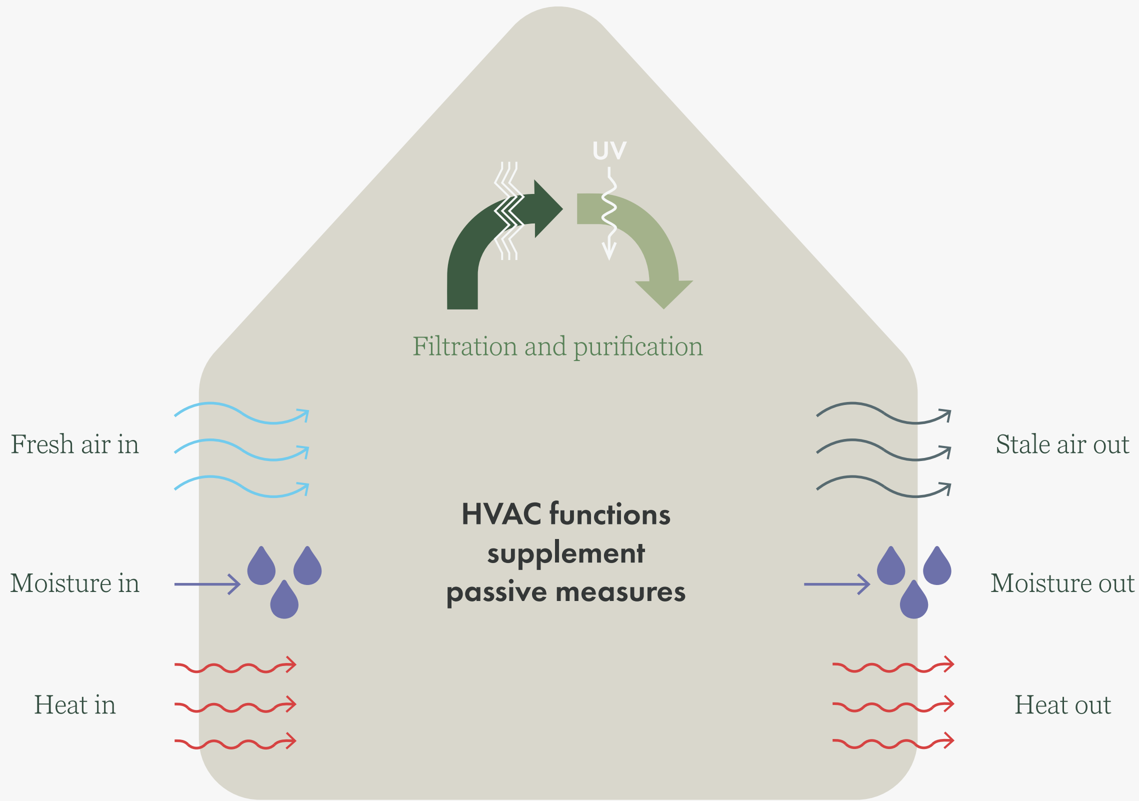
High quality envelopes pay for themselves: they reduce both upfront HVAC equipment costs and ongoing operating costs.

Active building system boundaries: Active building systems may be classified as either being entirely contained within the building system, and/or connected between the building system and the surrounding site and services infrastructure. Transportation and communications extend far beyond the site and services boundary.

Many active systems may be substituted with either passive measures, or active technologies which rely on site renewable energy systems.

It is important to recognize that active systems can never substitute for passive measures related to thermal resilience, since they are disabled during extended power outages.

A note on value-engineering: Higher quality envelopes reduce the size and cost of mechanical equipment. By prioritizing a high-performance envelope during value-engineering, HVAC systems and their subsequent operational costs can both be reduced, presenting more value than simply reducing the quality of the enclosure.



The important role of passive systems: Passive systems, not active systems, determine the peak energy demands for space heating and cooling. Active systems only satisfy these demands through the conversion of energy into conditioning of the indoor environment. While specific equipment types can convert energy more or less efficiently, they can do nothing to reduce energy demands—this is only possible through passive systems.

Bi-directional flows: Due to our climate, which ranges from -25°C to +35°C, energy and mass flows through the envelope change direction with the season. This presents unique challenges for architects and designers in the GGH, since envelopes cannot depend on traditional approaches to resilience that involve unidirectional drying. With climate change, these challenges will be further exacerbated.

Vernacular architecture in the GGH historically depended on extreme heat loss, high hygroscopic capacity, and high air leakage to protect structures from rot. Today, these approaches are untenable and unaffordable, and new approaches are needed.

Click here to view resources for future-ready HVAC technology.

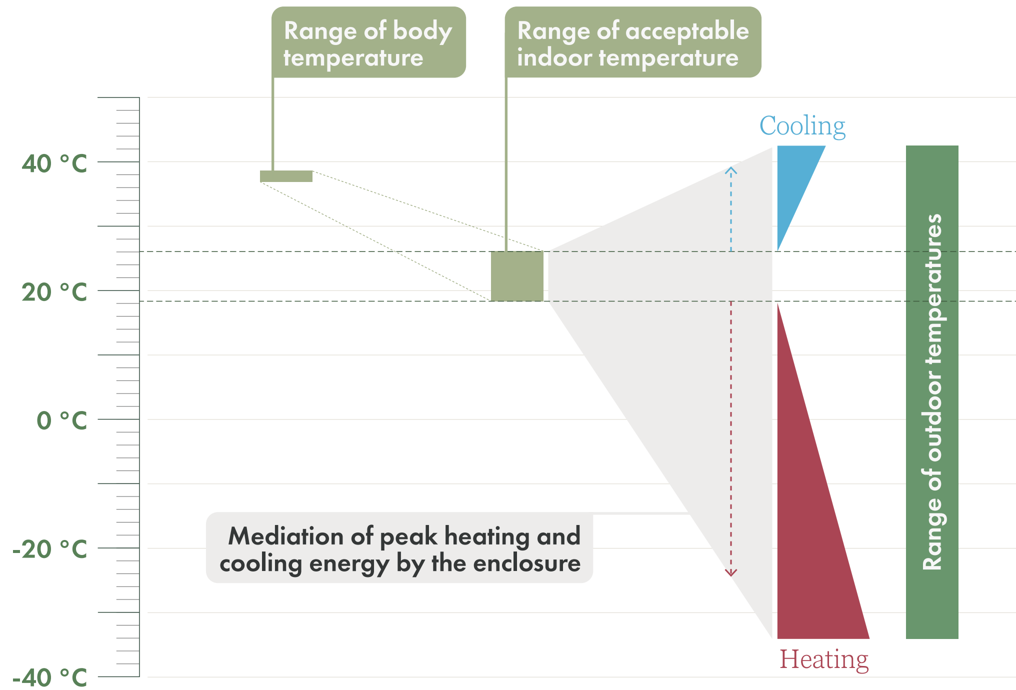
HVAC systems, comfort, and energy

Contrary to popular conception, heating, ventilating and air-conditioning systems do not deliver thermal comfort in buildings—they only supplement the passive systems with mass and energy flows. This is accomplished through four basic operations:

1. *Space conditioning* adds heat (heating) or removes heat (cooling).
2. *Ventilation* adds fresh air and removes stale air.
3. *Humidity* control adds water vapour to the air (humidification) or removes it (dehumidification).
4. *Filtration or purification* removes particulates and other contaminants from the air.

Passive systems determine comfort: Active systems are reactive solutions, whereas passive systems are proactive measures to reduce the amount of energy needed to maintain indoor comfort conditions.

Thermal comfort is almost entirely provided by the building envelope and only minimally supplemented by active systems in contemporary MURBs. HVAC systems cannot compensate for thermally inefficient enclosures, which can lead to cold or hot spots that cannot be addressed by HVAC.



The peak and annual space heating and cooling energy demands are largely determined by the overall effective U-value of the enclosure and its airtightness. Shading devices are critical to managing cooling loads. Overall U-value is strongly influenced by WWR and thermal bridging.

Click here to view resources for the measurement and verification of future-ready MURB performance.

Metabolism metrics and indicators

Buildings are prosthetic devices intended to shelter humans in environments conducive to their health and wellbeing. While medicine has developed highly specific and reliable indicators of human health, such a set of metrics and indicators do not yet exist for buildings. Without these figures, it can be difficult to make informed decisions during early stages of design, impacting performance.

Metrics vs indicators: A metric is something which can be physically measured. An indicator can be either quantitative or qualitative, providing insight into the state of a system or process in relation to a specific goal or objective. Metrics are the building blocks of indicators, while indicators are the interpretation of these metrics.

For example, the amount of electricity a building consumes can be measured by a meter. This metric may be interpreted in relation to benchmarking data from a sampling of similar buildings to determine if the building is energy efficient according to a set of criteria.

Often, a number of metrics must be jointly assessed to arrive at a higher order indicator. To keep things simple, metrics are absolute whereas indicators are relative and open to many possible interpretations.

Building vital signs

When assessing the metabolism of a building, there are many vital signs that can be measured and used to estimate the size of a building's ecological footprint, including:

- overall effective U-value;
- total energy use intensity (TEUI);
- thermal energy demand intensity (TEDI);
- greenhouse gas emissions intensity;
- peak energy demand intensity;
- thermal autonomy;
- passive habitability;
- potable water consumption;
- stormwater runoff; and
- solid waste generation.

Overall effective U-value: The overall thermal transmittance of the building enclosure—as opposed to its various components and assemblies—is referred to as its U-Factor. It is expressed as watts per m^2K (W/m^2K), and takes into account the reduction of insulation effectiveness by thermal bridging across all building components and assemblies. Along with airtightness, these two metrics are the most significant indicators of the annual and peak energy demands for space heating and cooling.

U-value is the rate of heat flow (watts) through one square metre (m^2) of material for each degree of temperature difference (Kelvin or °C) between inside and outside. It is the inverse of R-value, so the lower the U-value the better.

Typically, U-values are used to describe overall performance of a component or assembly, taking into account thermal bridges and other effects. R-values usually only describe a particular material, though it is often erroneously used to describe overall performance.

U-values and R-values are measured in metric (SI) and imperial units, and can be converted easily:

$$USI \times \boxed{0.176} = U_{imperial}$$
$$U_{imperial} \div \boxed{0.176} = USI$$

$$RSI \times \boxed{5.678} = R_{imperial}$$
$$R_{imperial} \div \boxed{5.678} = RSI$$

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Effective U- and R-values account for losses in the design. For example, a wall that is *nominally* R-22 will be *effectively* ±R-17, depending on the design.

Typical effective U-values and R-values

Existing MURBs, average of entire stock	USI-1.6 (RSI-0.62)	U-0.28 (R-3.5)
Contemporary glass window wall residential tower	USI-2.5 (RSI-0.40)	U-0.44 (R-2.3)
Future-ready MURBs	USI-0.81 (RSI-1.23)	U-0.14 (R-7.0)

Typical range of U-values and R-values of components in future-ready MURBs

	USI	RSI	U	R
Windows	1.50 - 0.95	0.67 - 1.05	0.264 - 0.167	3.80 - 5.96
Walls	0.28 - 0.19	3.57 - 5.26	0.049 - 0.036	20.26 - 29.87
Roofs	0.19 - 0.09	5.26 - 11.11	0.036 - 0.016	29.87 - 63.03
Slab-on-grade	0.57 - 0.28	1.75 - 3.57	0.100 - 0.049	9.94 - 20.26

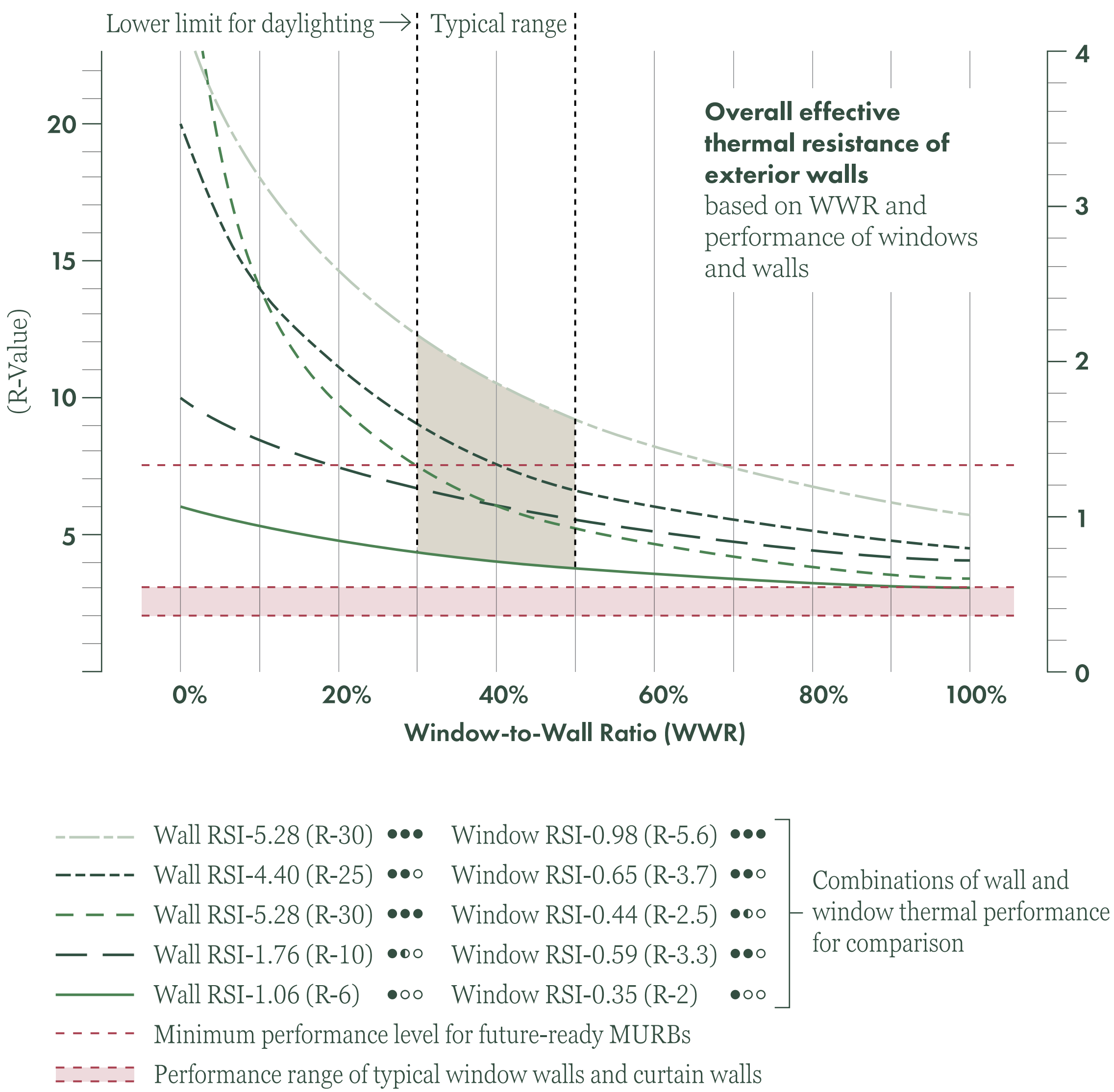
Passive House minimum performance (for comparison)

	USI	RSI	U	R
Windows	0.30	1.25	0.14	7.1
Walls	0.15	6.67	0.03	37.8
Roofs	0.15	6.67	0.03	37.8
Slab-on-grade	0.25	4.00	0.044	22.71

Achieving good U-values: Experience has shown that in order to meet energy performance targets in the various green standards across the Greater Golden Horseshoe region, an overall effective R-value for exterior walls of RSI-1.3 (R-7.5) is needed. Going below these values at the early stages of design will compromise the achievement of energy performance targets and likely require re-design of the enclosure during design development—an avoidable and costly effort.

The U-value of the building enclosure is strongly influenced by the window-to-wall ratio (WWR) of the exterior walls. Windows and their frames contribute significantly to losses due to their thermal conductivity and thermal bridging, lowering the overall effective U-value of any particular assembly.

Click here to view resources for building enclosure design.



Click here to view the *National Fenestration Rating Council database* for reliable window ratings.

Overall effective U-value: Understanding the relationship between opaque exterior wall effective thermal resistance values and the energy efficiency of windows is helpful in designing more responsive facades. It is possible to provide different wall and window R-values according to solar orientation in order to address other performance objectives. For example, larger north-facing windows for enhanced daylighting (e.g., 50% WWR) can meet energy targets by increasing the thermal efficiency of the opaque and glazed components. When these types of approaches are combined with the selection of different solar heat gain coefficients for glazing, and the addition of appropriate shading devices, facades can be tailored for each solar orientation without compromising energy performance and comfort. The thermal resilience of the building can also be improved for both weather extremes by differentiating facade designs according to solar orientations.

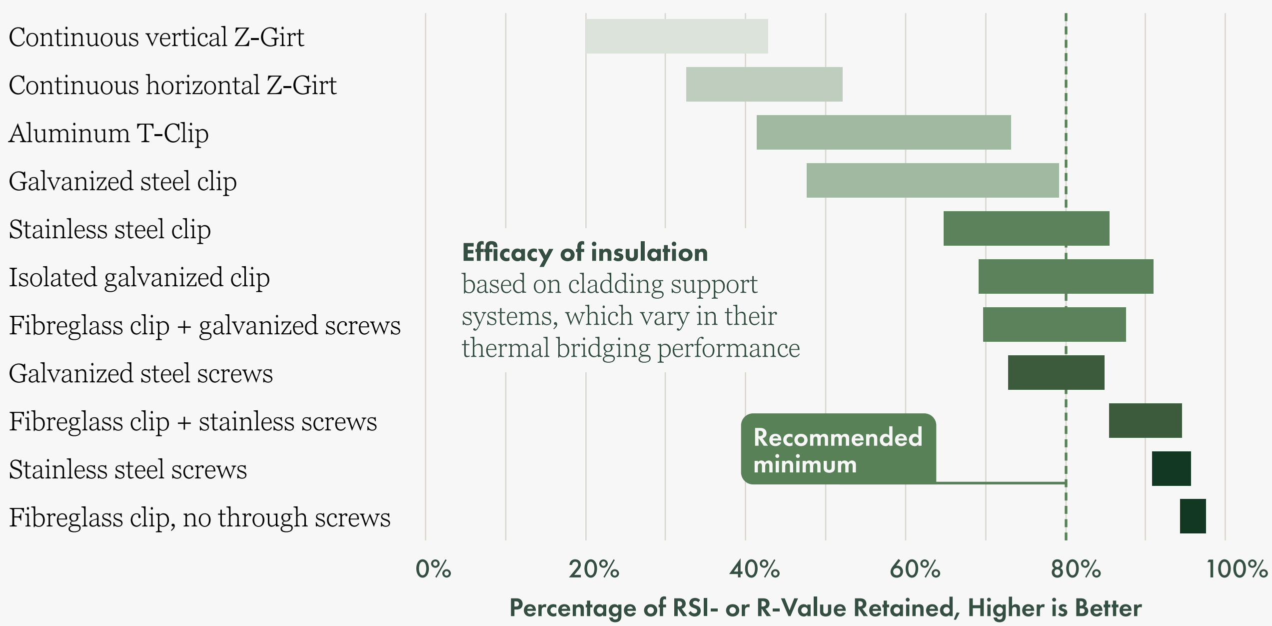
Windows are the weakest link in the thermal efficiency of exterior walls, so they must be carefully selected. Ensure the rating provides the effective U-value of the entire window, including frames.

The selection of appropriate insulation materials to achieve high-performance enclosures needs to consider the efficiency of the insulation (thermal resistance per unit of thickness), its effectiveness after accounting for thermal bridging effects, and its embodied carbon content.

Typical thermal resistance values of insulation materials

Embodied carbon: • High • Moderate • Low

Material	RSI		R		Embodied carbon (CO_2)
XPS foam board	RSI-0.88	*per 25mm*	R-5	*per inch*	High
Aerogel batt	RSI-1.69	*per 25mm*	R-9.6	*per inch*	High
Closed cell spray foam, HFC	RSI-1.16	*per 25mm*	R-6.6	*per inch*	High
NGX foam board	RSI-0.88	*per 25mm*	R-5	*per inch*	High
Vacuum Insulated Panels (VIPs)	RSI-5.28	*per 25mm*	R-30	*per inch*	High
Mineral wool board	RSI-0.74	*per 25mm*	R-4.2	*per inch*	Moderate
Closed cell spray foam, HFO	RSI-1.16	*per 25mm*	R-6.6	*per inch*	Moderate
EPS foam board (type II)	RSI-0.70	*per 25mm*	R-4	*per inch*	Moderate
Polyisocyanurate foam board	RSI-1.14	*per 25mm*	R-6.5	*per inch*	Moderate
Open cell spray foam	RSI-0.72	*per 25mm*	R-4.1	*per inch*	Moderate
Mineral wool batt	RSI-0.70	*per 25mm*	R-4	*per inch*	Moderate
Wool batt	RSI-0.70	*per 25mm*	R-4	*per inch*	Moderate
Fibreglass, blown-in	RSI-0.46	*per 25mm*	R-2.6	*per inch*	Moderate
Fibreglass, batt	RSI-0.63	*per 25mm*	R-3.6	*per inch*	Moderate
Hemp fibre batt	RSI-0.65	*per 25mm*	R-3.7	*per inch*	Low
Cellulose	RSI-0.65	*per 25mm*	R-3.7	*per inch*	Low
Wood fibre batt	RSI-0.69	*per 25mm*	R-3.9	*per inch*	Low
Hempcrete	RSI-0.37	*per 25mm*	R-2.1	*per inch*	Low
Wood fibre board	RSI-0.60	*per 25mm*	R-3.4	*per inch*	Low



Exercise caution: some insulation materials are extremely carbon intensive. In the GHG region, with its relatively green grid, a building may never offset the emissions of its insulation, doing more total harm than good.

Cladding support systems short circuit continuous exterior insulation, reducing its overall performance.

Since Vancouver first introduced an energy step code, the TEUI of MURBs has decreased year over year. New technologies, like heat pumps, have helped even more.

Total Energy Use Intensity (TEUI)

TEUI (kWhe/m²·yr) is a measure of a building's total annual energy consumption per unit area, accounting for all energy used for heating, cooling, lighting, ventilation, water, equipment, and other end uses. TEUI normalizes all energy sources—like electricity, gas, district steam, and others–into "kilowatt-hours equivalent" (kWhe) in order to make comparative apples-to-apples analyses possible.

Energy step codes: Energy step codes, first introduced by Vancouver in 2017, have significantly reduced the total energy use intensity of MURBs, altering their metabolism. Over the past several decades energy use intensity has been reduced by two-thirds. High-performance building envelopes and heat pump technology have reduced space and water heating energy consumption dramatically.

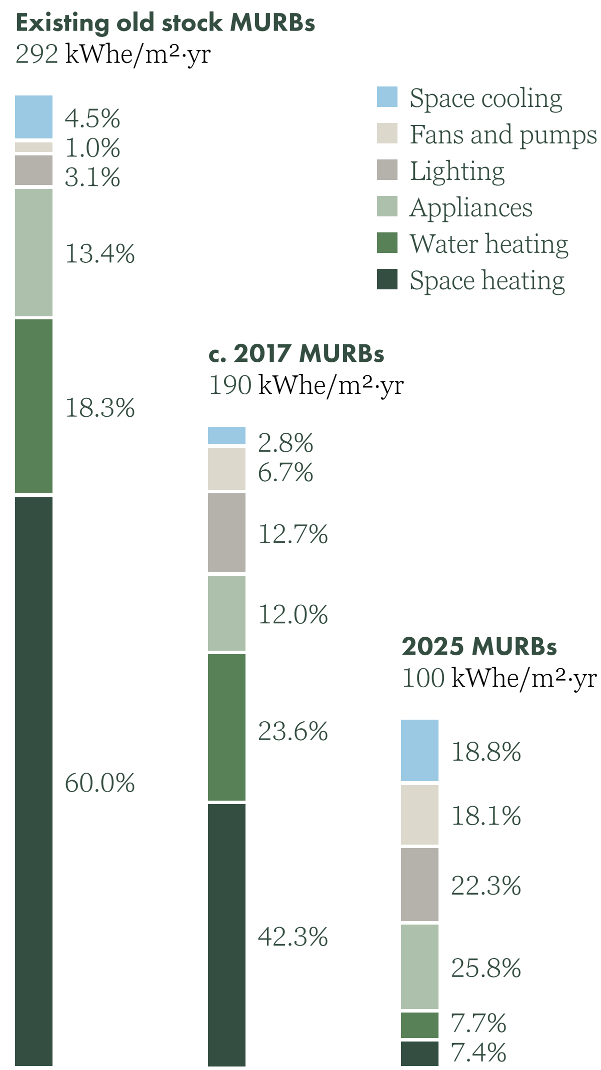
Evolving energy use: Existing MURBs have thermally inefficient envelopes and high rates of air leakage. These deficiencies result in space heating being the dominant demand for energy, followed by domestic water heating.

As building envelope performance improved, space heating and domestic hot water energy use proportionally diminished, becoming smaller shares of overall TEUI. The recent move away from fossil fuels to heat pump technology, coupled with high performance envelopes featuring minimal thermal bridging, has completely inverted MURB metabolisms in relation to space and domestic water heating energy demands. Space cooling has become a major consideration that can only be expected to increase in significance across the GGH region due to climate change.

Recent studies of energy use intensities in existing Toronto MURBs reveal a very high range—from as low as 90 kWhe/m2.yr to 580 kWhe/m2.yr—more than a factor of 6 times between the lowest to the highest. The MURB building stock analyzed in these studies included buildings from 1952 to 2008, with 80% of the buildings in both studies having been built between 1961 and 1980.

It is worth noting that low energy MURBs with EUIs less than 100 ekWh/m2.yr exist and were constructed and occupied long before the introduction of green standards in Toronto.

Worst performing MURBs are up to 6x more consumptive
of MURBs built in Toronto between 1952 and 2008



Low intensity HVAC systems, which are smaller and more efficient, can only be deployed in buildings that with high performance envelopes.

Thermal Energy Demand Intensity (TEDI)

TEDI uses the same units as TEUI (kWhe/m²·yr), and is a metric that measures how much energy is needed for a building's space heating, cooling, ventilation, and domestic hot water heating.

Unlike TEUI, which measures total energy consumption including inefficiencies in mechanical systems, TEDI looks at raw demand for thermal energy, ignoring any advantages or disadvantages conferred by equipment. Naturally, this encourages better passive design strategies and envelope performance, rather than reliance on better or worse equipment. For these reasons, step codes, green standards, and other programs tend to use TEDI instead of TEUI.

Like TEUI, TEDI is normalized to gross floor area. While this may seem intuitive, it does not meaningfully correlate energy demand to occupancy. Hot water and ventilation, for example, are more tied to the number of occupants than the size of the building. Architects and designers should feel free to normalize TEDI to a per capita basis in order to better inform design decisions.

TEDI is changing—for good reason

Originally derived from the Passivhaus Standard, TEDI included all thermal loads including ventilation, which was assumed to have somewhat constant airflow rates based on typical households. As the standard evolved to include multifamily housing, it was recognized that ventilation loads increased on a floor area basis to the point where it was challenging to meet energy performance targets: allowable thermal energy per m^2 of floor area is harder to achieve when the area per occupant is less. A similar trend was observed with domestic water heating.

To address this inequity, European building performance targets have begun separating energy demand for space conditioning (heating and cooling) from energy demand for ventilation and domestic water heating, based on the following rationale:

- TEDI should be a metric for building enclosure performance—a *passive* measure that involves overall effective thermal resistance, SHGCs, and airtightness. The enclosure is a fixed asset and its properties and performance do not change with occupancy. When the occupancy in a building changes, its ventilation requirements change, but the properties of the enclosure remain constant.
- Mechanical ventilation and domestic hot water are *active* systems whose energy demands vary with occupancy, not so much with floor area. While ventilation demands energy, it is essential to health and safety—it is not something that is at the discretion of the designer. Hot water use is highly variable and tied to the habits of particular occupants for a particular building.

Modern TEDI metrics no longer bake-in active systems based on typical occupancy and building areas. Instead, modern TEDI metrics only consider enclosure components, shading devices, and airtightness. Ventilation is regulated separately by ventilation effectiveness, energy recovery efficiency, and demand controls. Domestic water heating is regulated separately through fixture and appliance efficiency, along with efficiency standards for water heating equipment.

Fixed assets should be judged on fixed characteristics. Occupants come and go. Both should be evaluated separately.

Peak Energy Demand Intensity (PEDI)

PEDI (kW/m^2) refers to the highest one time power consumption rate during a specific time period, often measured in energy use per m^2. It is a useful metric for understanding a building's energy efficiency and its impact on the electrical grid.

This intensity can fluctuate significantly based on factors like building type, occupancy, and climate. In the GGH, peak energy demands from the electrical grid are challenging our ability to provide sufficient and affordable electricity to meet population and economic growth. Peak demand periods are when Ontario activates natural gas power plants—a polluting source of electricity—in order to keep up with supply. Higher and more frequent peaks, which are forecast, will result in more GHG emissions and an overall dirtier grid.

PEDI is not one of the commonly required performance metrics in step codes and green standards. This is likely due to the implicit correlation between other performance targets and peak energy demands. However, the cost of electricity in large buildings is impacted by peak demands, when electricity is most expensive. Failure to manage peak demands also has implications for the need to expand our electrical energy grid.

Recent research into the influence of passive measures on MURB energy demands for space heating and cooling are revealing. Peak energy demand for heating can be reduced by approximately 60%, and 50% for cooling—all from passive design measures. The key variables in achieving these reductions were thermal efficiency of the envelope, airtightness and WWR, with energy recovery on mechanical ventilation also making a significant contribution.

It is also possible to use thermal storage of hot and chilled water to offset peak energy demands—a strategy that is quite common in countries with very high electricity costs and limited grid capacity.

Occupant behaviour is always a significant influence on peak energy demands. Activities such as laundry, dishwashing, and car charging can significantly reduce peak demands if they are carried out during off-peak hours.

Greenhouse Gas Emissions Intensity (GHGI)

GHGI (kgCO_{2e}/m^2·yr) refers to the amount of GHG emissions produced by a building, measured as kilograms of carbon dioxide equivalent (CO_{2e}) per m^2 per year. It is a key metric for understanding and managing the environmental impact of buildings, which are a significant contributor of GHGs.

CO_{2e} is a measure that was created by the United Nations' Intergovernmental Panel on Climate Change (IPCC) in order to make the effects of different GHGs comparable. The purpose of GHGI targets in codes and standards is to both reduce the total demand for energy, but also to choose energy sources that are low in carbon. GHGI targets help promote the development of a clean energy supply.

?

Kilowatts (kW) measures the rate of energy usage. It's analogous to speed—for example, how fast you're walking. A microwave uses about 1 kW of energy.

Kilowatt-hours (kWh) measures the quantity of energy used over time. For example, how far you've walked after an hour. Run a microwave for an hour and you'll use about 1 kWh of energy.

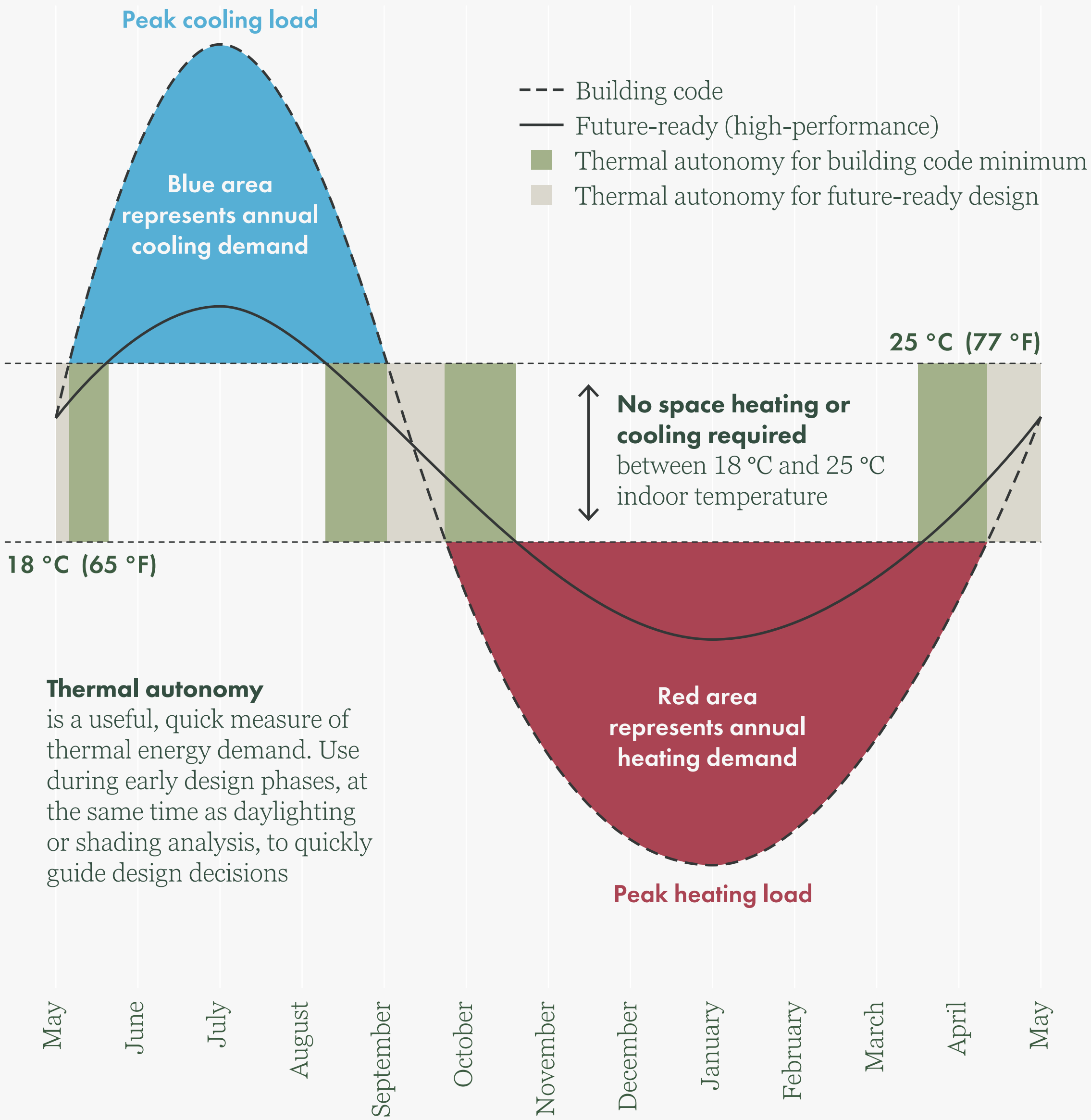
?

GWP is a measure of how much heat a greenhouse gas (GHG) traps in the atmosphere compared to CO_2.

HFCs are a gas used to blow spray foam insulation during installation. HFCs have a GWP of over 1,000. This means 1 kg of HFC released into the atmosphere would be the same as 1,000 kg of CO_2.

!

For a single family house, you might install about 300 m^2 of spray foam at 2" thickness, releasing ±50 kg of HFC. **That's the same as driving a mid-size gasoline car 250,000 km.** In Ontario's grid, those emissions will never be offset, doing more harm than good.



Thermal autonomy
is a useful, quick measure of thermal energy demand. Use during early design phases, at the same time as daylighting or shading analysis, to quickly guide design decisions

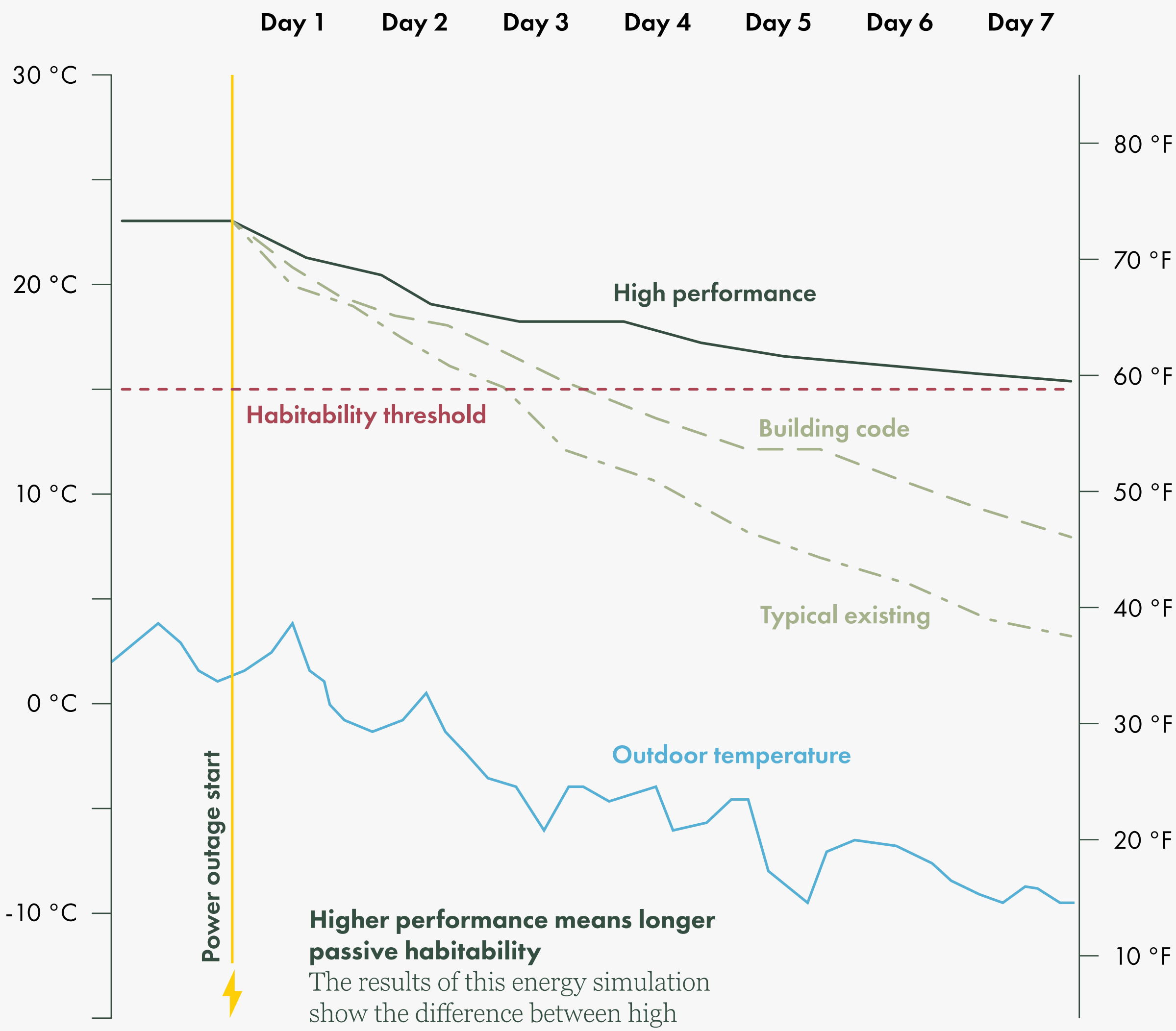
Thermal autonomy

Thermal autonomy is the percentage of time over the course of a year when a building's interior temperature remains between 18 °C and 25 °C—the comfort zone—without active cooling or heating systems. The higher the thermal autonomy, the lower the operational energy consumption and the more resilient the building.

Thermal autonomy is relatively simple to calculate using energy modelling software: turn off all active systems and run a simulation to see how many hours fall within the 18 °C - 25 °C indoor temperature range. Analysis of these results can quickly assess the benefits of designing different facades that respond to their respective solar orientations.

What impacts thermal autonomy? For heating: insulation (low U-values or high R-values) and better airtightness. For cooling: SHGC, shading, and natural ventilation.

In the GGH region, it is not feasible to design MURBs that require no heating or cooling throughout the year. But reduced dependence on active heating and cooling systems can be achieved through high-performance envelope design.



Higher performance means longer passive habitability
The results of this energy simulation show the difference between high performance, code, and existing building enclosures for a winter power outage scenario

[Click here](#) to view resources for resilient building design.

Passive habitability

Passive habitability measures how long an indoor space remains habitable following a prolonged power outage in extreme weather (when power outages are most likely to occur). Passive habitability includes measures to protect infrastructure, such as preventing the freezing of water pipes or the overheating of perishable belongings.

Hot and cold weather each have their own habitability metrics; however, hot weather habitability is much more challenging due to climate change. Warming temperatures will make it more difficult to shed heat through natural ventilation; instead, it may be necessary to provide a place of refuge that is equipped with backup power for air conditioning.

Of course, passive habitability cannot be maintained indefinitely, but at a minimum is should provide sufficient time to evacuate vulnerable individuals from buildings during scenarios where many such individuals may be seeking shelter simultaneously.

Strategically addressing passive habitability requires the modelling of various scenarios. To do this accurately requires consultation with local authorities to determine reasonable timeframes for power restoration and emergency first-responders.

Finally, typology matters: while passive habitability is critical for housing, it is much less important for offices or commercial buildings.

Passive measures will never go out of style

In the days before HVAC, building occupants and designers were extremely aware of the importance of passive design. Climate change is forcing us to rediscover the importance of passivity, a critical feature of resilient buildings.

Wildfires, flooding, and extreme temperatures are becoming increasingly normal. So is the disruption of critical infrastructure like potable water. Passive measures will keep people safer for longer.

Legend: ● Critical · ● Recommended · ○ Optional

	High Thermal Insulation	40% < WWR > 60%	Low SHGC Glazing	Continuous Air Barrier	Reduced Thermal Bridging	Shading Devices	Natural Ventilation
Cooling Dominated Climate	Recommended	Recommended	Critical	Critical	Optional	Critical	Critical
Temperate Climate	Recommended	Recommended	Recommended	Critical	Recommended	Critical	Critical
Heating Dominated Climate	Critical	Critical	Optional	Critical	Critical	Recommended	Recommended

The GGH will have broad passivity requirements due to extreme weather, which will bring both heat waves and cold snaps

Changing climate and passivity

Passive measures are necessarily climate-specific, and the climate of the GGH will become more temperate than heating-dominated in the near future. However, climate change will also result in extreme events with greater thermal swings—from cold snaps to heat waves.

In practice, this means that MURBs in the GGH designed today should, while avoiding expensive mechanical systems, be ready to:

- handle extreme cold snaps in January
- stay habitable during August blackouts
- avoid overheating mid shoulder seasons

Reducing potable water consumption

Canadians are amongst the highest consumers of water in the world, impacting energy consumption for water treatment, heating, distribution, and sewage.

Clean water is a finite resource and water conservation is forecast to become the next energy crisis.

In 2021, Statistics Canada reported that Ontario's residential sector used an average of 187 litres of water per capita per day. A recent benchmarking study of existing Toronto MURBs revealed that the range of annual water consumption ranged from 56 m^3 to 550 m^3 per unit, or 153 to 1507 litres per unit per day—a massive 10x range. Energy for water heating and GHG emissions from municipal water treatment were found to be significant and correlated to water consumption.

Intensification of our urban regions will strain the limited capacities of existing infrastructure. Future-ready MURBs should implement low-flow plumbing fixtures, water efficient appliances, and high-efficiency domestic hot water heaters.

Sub-metering for energy and water use is also highly recommended. CMHC reports found that consumption increased drastically when units were not sub-metered and billed individually. Sub-metering gives direct feedback on resource consumption to occupants, altering habits and ultimately reducing energy and water usage.

> ⚠ Hotter water uses more energy to heat. Considering setting water heating a few degrees cooler while still hot enough to control legionella.

Flooding is costing buildings more and more. On-site stormwater management is a cost effective way of preventing flooding and is already required by many jurisdictions.

Stormwater management reduces risk, costs less, and increases value

Climate change will be costly, and flooding is a large reason why. Outdated sewage and stormwater infrastructure has not kept up with the growth of cities, leading to increasingly common and severe flooding. Upgrading this infrastructure is often financially or technically infeasible in built-up urban areas, leaving building sites vulnerable to flooding.

Luckily, it is inexpensive to provide buildings with reliable, passive measures that absorb or hold on to rainwater, instead of letting it back-up into homes or onto streets. Many municipalities in the GGH and around the world have adopted wet weather flow regulations for this reason.

Strategies for stormwater management

There are many, well-understood and proven strategies for managing stormwater on-site.

Green roofs: Green roofs use vegetation and growing medium to absorb and hold on to stormwater, allowing it to slowly evaporate into the air. This redirects stormwater from catch basins into plants and the atmosphere.

Note that green roofs can become a maintenance burden if not improperly designed and specified. Green roofs require careful consideration of both the ecology and climate of the immediate surroundings to ensure survivability of plants with little inputs.

Permeable hardscape: Hard landscape finishes are necessary to provide accessible pedestrian and vehicular paths of travel. Many hardscaping products already exist on the market which allow stormwater to infiltrate through the product into the ground below.

Some permeable hardscaping works by creating widened joints between units, like pavers, which enable water flow. Others, like porous asphalt and concrete, look like their conventional counterparts but contain large, interconnected voids that pass water. Other products use cellular grids made of plastic or concrete that provide rigid reinforcement to gravel or grass—a resilient and inexpensive solution for parking lots, for example.

Bioretention areas: Shallow, landscaped depressions in the landscape can be designed to capture, filter, and absorb stormwater runoff using plants, soils, and drainage. This is one of the most common Low-Impact Development (LID) strategies in use today for its low cost and aesthetic potential. However, this strategy does require sites with sufficient space to host such a feature.

Vegetated or dry swales: Swales are gently sloped channels in the landscape that convey, slow, and partially treat stormwater runoff. Vegetated swales, also known as grassy swales, use vegetation to trap contaminants, and are already common alongside roads and parking lots. Dry swales are more engineered, using soil amendments and sub-drains to promote infiltration into the ground. Because they are more engineered, dry swales are often better at treating stormwater runoff and can provide infiltration even when the underlying soil is poor.

Rainwater harvesting: Cisterns, barrels, and other systems can be used to capture stormwater for non-potable uses, such as irrigating plants, flushing toilets, or washing clothes.

Click here to view resources on flood protection by the *Intact Centre on Climate Adaptation*.

Downspout diversion, disconnection, or redirection: Many older buildings directly connected their downspouts into municipal sewage infrastructure. With growing cities, this is no longer possible, and existing connections create strains on sewage infrastructure which have led to contaminated water bodies.

Disconnecting, diverting, or redirecting downspouts is as the name suggests. Instead of dumping rainwater into the sewer, it is conveyed to vegetated landscape features (also known as rain gardens) or any other stormwater management strategy discussed here.

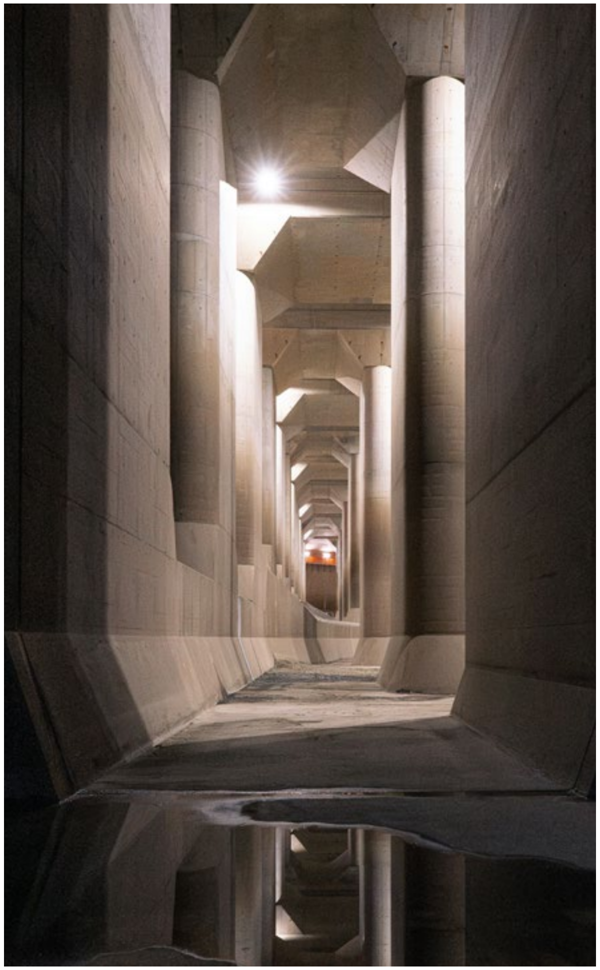
Pollution control: On-site stormwater management also includes treatment, since parking lots and buildings can release salt, oil, heavy metals, microplastics, and other contaminants into runoff. Green roofs, bioretention areas, and swales already contain filtration features. Curb pollution at the source by avoiding pollutants altogether, such as de-icing salt (some permeable pavers prevent ice formation altogether). Engineered products, such as oil-grit separators, are also commonly used.

Quantifying stormwater

One of the most useful metrics in stormwater management is the percentage of rainfall that becomes surface runoff during frequent storm events or over the course of a year (% runoff). Lower isn't always better since some overland flows may be necessary to divert water to receiving bodies.

Runoff should not exceed pre-development rates, nor cause erosion, and should be free of contaminants. During early stages of design, it is important to engage a qualified hydrological engineer to explore design options.

Allied professionals: Architects and owners should collaborate with landscape architects, who can add significant value during early design stages by integrating stormwater management into cohesive whole-site strategies. It may also be worthwhile to engage ecologists, particularly around sensitive sites.



Engineered stormwater infrastructure is costly: the Tokyo G-Cans system, pictured above, cost $5.5 bn Canadian dollars (adjusted for 2025) - *Photo by C Cai on Unsplash*

Solid waste management

Managing solid waste—or garbage, compost, and recycling—reduces stress on landfills and maximizes resource recovery. Municipal services charges for solid waste removal have increased dramatically across the GGH. However, enabling low-friction composting and recycling is often overlooked in MURB design.

A recent study on existing Toronto MURBs revealed that the volume of solid waste generated per unit ranged from 1.2 to 13.3 m^3 per year. This high range between the lowest and the highest underlines the importance of designing waste management facilities in MURBs that are convenient, accessible, and foolproof.

Building and site plans should provide adequate and efficient waste handling facilities for all waste streams. Review municipal solid waste, recycling, and composting guidelines that apply to new building projects at early stages of design, since these may affect circulation and site design.

If handling composting and recycling is any more difficult than handling garbage, residents will tend to combine all three streams into garbage. Designing for convenience is key to better resource recovery.

Toronto's Green Lane Landfill, located 200 km west of Toronto, is nearing capacity - *Map data © 2015 Google*

Energy modelling is both a design and a compliance tool. While it's important to demonstrate that a proposed design will comply with mandated targets, it is more important to use modelling tools to give buildings minimal but resilient metabolisms.

The earlier these tools are used, the easier they are to use.

Metabolism and performance targets don't always tell the whole story

It is important to appreciate that achieving or exceeding all performance targets is not necessarily an indicator of sustainability. Building metabolism is related to morphology and materiality; two buildings with identical metabolisms may have very different life cycle ecological footprints. This emphasizes the vast leap in complexity that now challenges architects designing future-ready buildings. Architects are urged to avoid trade-offs between passive and active systems that compromise resilience.

Building energy simulation is imperfect: Simulation technology for buildings has come a long way, yet there often remains a significant gap between the predicted and actual performance of most buildings. This is referred to as the *performance gap*.

Experienced energy modellers know that a building's TEUI can vary widely depending on how the building is used—even if its physical design stays the same. Take a typical elementary school: if it's only open during school hours, it will have low energy use. But if the building is instead used for community programs on evenings, weekends, and throughout the summer, the TEUI will rise significantly, even while none of the passive design features have changed.

This highlights an important point: energy models are not perfect. But they're still useful, especially when used to compare different design options. Rather than trying to predict exact energy use, models are most effective when estimating the *relative* performance of alternatives. For example, if a proposed set of energy conservation methods (ECMs) is modeled to reduce energy use by 50% compared to baseline, that same general reduction is likely to be observed in the real world.

The key is to focus on factors that have the biggest impact in a building's overall performance—its metabolism. Where current codes or standards fall short, practitioners can set their own internal performance thresholds to guide better outcomes.

> *All models are wrong, but some are useful.*
>
> — George E.P. Box, Statistician, 1976

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A building's metabolism is influenced by passive and active systems. Architects can only directly address passive systems—make the most of it!

Creating a good building metabolism

At the early stages of design it is important to establish a set of guiding principles that minimize a building's metabolism. Morphology—massing, geometry, and solar orientation—must be taken into account when applying these principles.

The materiality of the building's control layers comprising the enclosure are equally critical to achieving a balance between upfront, recurring, and operational carbon.

Metabolism is multivalent and needs to be considered from multiple perspectives. For example, a swimming pool will increase metabolism, and so will electric car chargers. But car chargers offset fossil fuel emissions from transportation; impacts must be considered holistically.

Click here to view resources about the metabolism of MURBs.

Recipe for a good metabolism

- ☐ *Passive systems first:* Active systems come and go, but the armature and envelope must endure and deliver resilience.
- ☐ *High performance enclosure:* The thermal efficiency of the building envelope is the most cost-effective line of defence against an unsustainable building metabolism. Savings from downsized HVAC systems pays for enclosure premiums.
- ☐ *Low intensity thermal energy:* The capacity of efficiency of heat pumps is significantly enhanced when low intensity HVAC systems are deployed. These systems do require a high performance envelope.
- ☐ *Solar responsive design:* Facades should reflect their solar orientations and take shading devices and window sizes for daylighting into account.
- ☐ *Shading devices and operable windows:* Passive cooling depends on the control of solar gains and natural ventilation. Single aspect facades need large window opening areas (the maximum 100 mm window opening size mandated by the OBC is inadequate). Plan for larger, protected, and/or high openings.
- ☐ *Separate HVAC functions:* Don't combine ventilation with heating and cooling—thermostats do not detect indoor air quality, and ventilation is often required without heating or cooling. Give occupants the knowledge and ability to control these functions.
- ☐ *Stormwater management:* Reduce runoff rates to pre-development levels (how the original, undisturbed landscape managed stormwater before buildings, roads, etc.).
- ☐ *Conserve water:* Specify low flow plumbing fixtures and water efficient appliances. Design landscapes that require less irrigation, or harvest rainwater for use.
- ☐ *Make composting and recycling easier:* Studies show that pleasant, convenient composting and recycling facilities dramatically increase their use. Don't overlook this aspect of MURB design.

Economics

Architects operate within a complex housing economy shaped by forces largely beyond their control—but that doesn't mean they lack influence.

Through thoughtful design, life cycle costing, and future-ready strategies, they can meaningfully improve affordability, resilience, and long-term value.

Conventional financial metrics often fail to capture these benefits, focusing instead on short-term returns. A broader perspective—one that considers diverse stakeholders and long-term societal outcomes—positions architects as key contributors to housing solutions that are both economically and environmentally sustainable.

Economics is, largely, outside the scope of architects. The field is complex and influenced by factors beyond the control of governments, let alone design professionals. But there are aspects of economics related to housing that can be positively impacted by better design and project management practices.

Housing and economics

The economics of housing has many dimensions. It is important for architects to appreciate that most of these are beyond the influence of designers. But there are still many opportunities to favourably impact the economics of MURBs.

Economic dimensions of housing encompass its significant impact on the economy, affecting everything from individual wellbeing and affordability to overall economic growth and stability. Housing is a crucial component of national income accounting, contributing to both investment and consumption, and its market dynamics play a vital role in shaping economic cycles.

The economy follows housing: The Canadian housing market significantly impacts affordability, wealth accumulation, investment, and employment. Rising home prices and interest rates play a key role in household savings and investment, while broader impacts are felt in resource extraction, manufacturing, and other related sectors.

Overall, a significant share of Canada's GDP stems from housing, even more so than in other developed nations. Housing also accounts for the largest Canadian household expenditure, followed by food and transportation. This being the case, the cost of housing severely impacts competitiveness of Canada's workforce, which will require higher wages to offset the rising cost of living.

According to Statistics Canada, as of 2021, housing remains the largest single spending category for Canadians. One-person households spend more on housing than couples (with or without children), and lone-parent households.

Portion of Canadian household spending on housing, followed by transportation and food

Portion of Canadian household wealth as real estate equity

Canadian homeowners' net worth is, on average, 4x higher than renters

Inequities between renters and owners are growing. Research published in 2025 by the CMHC revealed that high housing costs have hampered mobility, preventing people from moving towards better job opportunities. This reduces the productivity and

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growth overall by creating inefficiencies (people live further away from jobs). The sustainable economic growth of the GGH requires access to good housing that is close to work.

Housing and health: Housing isn't just a social issue—it's also a public health crisis with substantial costs to individuals and the healthcare system in Ontario and across Canada. Poor housing conditions, such as overcrowding, disrepair, inadequate heating or cooling, and unaffordability, are linked to both mental and physiological health challenges.

Let's talk numbers—what can architects do?

Innovation in construction techniques, materials, and other systems can provide marginal cost savings. Even modular construction—both volumetric and panelized—have yet to realize significant real cost efficiencies at scale. Buildings, especially in tight urban sites, are bespoke, one-off projects situated on unique sites with unique requirements.

Ultimately, life cycle cost is where architects have the most influence. Typically, the life cycle cost of housing is reported as a Net Present Value (NPV)—in other words, the dollar value that would have to be paid today to cover all costs of a building over its life. NPV is often used to help clients understand the long-term benefits of future-ready design by demonstrating the pay-off of higher upfront investments into a better building. NPV takes into account the time value of money (inflation, forgone investment returns, risk), recognizing that a dollar today is worth more than a dollar tomorrow.

?

Net Present Value (NPV) recognizes the decreasing value of money over time, and is used as a tool to assess whether the long-term savings from a design decision are worth the upfront investment. Architects don't need to know this formula, but it may be useful for some:

$$\text{NPV} = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} - C_0$$

Where:

B_t = benefit (like energy savings) in year t
r = discount rate
t = year number (1, 2, 3, ..., n)
C_0 = initial cost

The *discount rate* is mainly influenced by opportunity cost (if the money were invested instead of spent on the building), with inflation and risk acting as key modifiers. Public-sector projects may use a lower discount rate to reflect social benefits or climate responsibility.

Simplified example
Gas furnace vs heat pump

	Gas furnace	Heat pump
Upfront cost	$5,000	$10,000
Extra cost	—	$5,000
Annual energy savings*	—	$750
Lifespan (years)	—	15
Discount rate	—	5%
Total adjusted savings	—	$8,571
Net Present Value	—	+$3,571

**Remember that NPV calculations actually reduce the amount of savings each subsequent year, reflecting the time value of money. In this example, $750 is saved the first year, but each subsequent year saves less. Yet the heat pump still comes out ahead.*

The example above shows that after 15 years, with inflation, opportunity cost, and risk factored, the building operator would still come out ahead by spending more upfront on a heat pump. In fact, this example is likely conservative, as it does not account for any rebates or carbon pricing.

Of course, like most economic evaluation models, this does not capture all benefits. Not polluting the air, for example, has obvious economic benefits; but quantifying these benefits for a particular project is hard. Some values are not easily quantifiable.

Key considerations for economics of housing

Housing economics is multidimensional

Long-lasting affordability will not come from solving one problem; instead, it spans multiple disciplines, and is judged by different metrics depending on the agenda: ROI for investors, affordability for households, cost-per-unit for developers, and life cycle cost for architects.

Is housing a right, or a commodity?

Housing in Canada has increasingly become a speculative investment vehicle, treated as a financial product instead of a basic human need. This commodification has severely distorted its primary function: providing shelter, stability, livability, and community continuity. Housing isn't priced for individuals and families, but for people with portfolios. No amount of architectural ingenuity ("*innovation*") can override these effects.

Affordability is about income, not just cost

It's a common misconception that affordability is a design problem. But the reality is that affordability is also a function of income distribution. Stagnated wages in Canada have come up against the rising cost of housing, and no amount of design optimization will bridge that gap.

The floor to cost cutting is real

Ultimately, there is a hard limit to how much costs can be driven down through value engineering. Codes, occupancy standards, and cultural expectations create a minimum standard which is not possible, or desirable, to go below. Smaller suites have diminishing returns, and cheaper upfront solutions leads to long-term operational burdens for occupants. Intergenerational costs are not captured by short-term economic models.

An architect's influence on cost is limited

While architects have the ability to affect approximately one-third to one-half of a building's capital costs, the reality is that architects have already, for the most part, hit the floor of what can be ethically or functionally cut. The rest is outside of their control—land acquisition, servicing, development charges, financing costs, permit fees, and legal overhead.

Architects can control costs, but not eliminate them

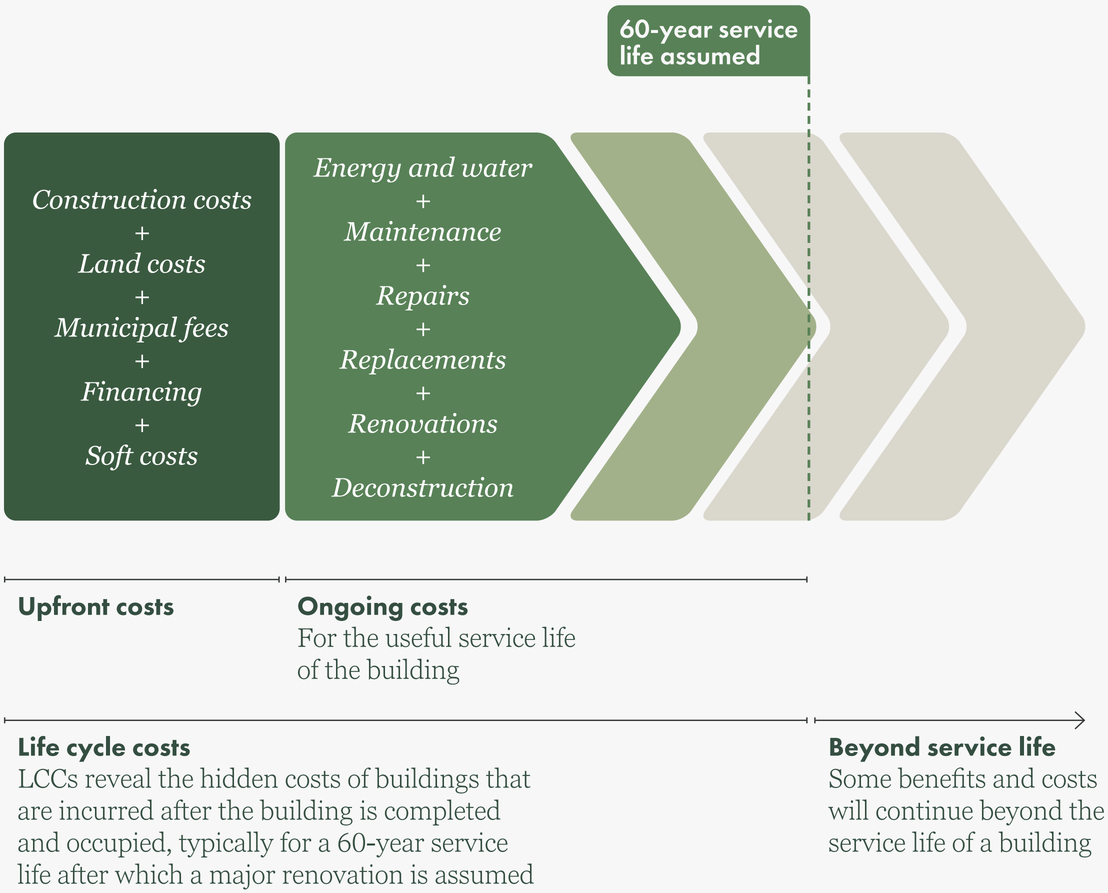
Architects can help ensure cost predictability by producing well-coordinated, thorough construction documents that minimize change orders and "extras" during construction. They can also embed long-term cost savings through passive design strategies, durable materials, and efficient layouts that minimize waste.

Stewardship and livability must remain central

Economic efficiency must not come at the expense of livability or environmental responsibility. A future-ready approach to housing economics considers not just how much a building costs today, but how it performs over decades. That means thinking in terms of stewardship—of resources, of communities, and of future occupants. The real value of housing lies in how it serves people, not just how it serves markets.

Payback period doesn't always apply to homes

Many housing decisions are evaluated using commercial real estate metrics like payback period or internal rate of return. But housing isn't a revenue-generating asset in the traditional sense. The most appropriate economic lens is life cycle cost: a long-term assessment of how much it takes to build, operate, maintain, and renew a building over its lifespan. These costs are borne not just by owners, but by society at large, especially when poor design leads to premature obsolescence.



Life cycle cost of housing

In the same way that the whole life carbon footprint of a building is evaluated using life cycle analysis (LCA), the whole life cost of a building can be estimated using life cycle costing (LCC). In fact, LCC is the preferred economic analysis method for future-ready MURBs because it runs parallel to whole life carbon analyses and provides valuable input to early stages of design.

ASTM E917-17 (2023) is recognized as the most comprehensive method of conducting LCCs. The standard is part of ASTM's Standards on Building Economics, which includes other economic measures such as payback and internal rate of return. LCCs are particularly suitable for determining whether the higher initial cost of a building or building system is economically justified by reductions in future costs.

Applied to buildings or building systems, LCCs encompass all relevant costs over a designated study period, including costs of design, acquisition, construction or installation, operation, maintenance, repair, replacement, and disposal.

Cost consultants can be engaged by architects to conduct LCCs, as well as any number of other analyses to inform design decisions.

Short-term metrics undervalue good design. Life cycle costing helps make the case for long-term performance and resilience.

Payback periods and IRR undersell the benefits of future-readiness

Conventional financial metrics like payback period and internal rate of return (IRR) are often misapplied when it comes to evaluating building future-readiness upgrades.

Payback undersells benefits. It only tells you how long it takes to recover an initial investment, but completely ignores ongoing benefits that continue to accumulate long after the payback period ends. It also overlooks the potential for higher building valuations that come with improved performance.

Internal rate of return (IRR) only caters to investors looking for a short-term return. It calculates the effective annual rate of return expected from an investment—but only works well when the investor intends to flip the asset within a few years. Architects in their duty have longer horizons than this, as they look out over the lifespan of a building.

Instead, LCC offers a more accurate and accountable way to evaluate economic performance across the lifespan of a building. But even that has its limits. Housing brings together a wide range of economic interests: for residents, it's affordability or stable monthly costs; for institutions, it's about long-term financial security and reliable returns. And at a national scale, housing affordability directly impacts Canada's ability to attract and retain talent for a competitive workforce.

Stakeholder perspectives on housing economics

	Primary considerations	Time frames	Economic measures
Developer (condo)	◦ Upfront costs ◦ Marketability	◦ Land acquisition to final sales and warranty holdback	◦ Internal rate of return (IRR)
Developer (landlord)	◦ Upfront costs ◦ Operations and maintenance ◦ Rentability ◦ Short payback period on upgrades above OBC minimums ◦ Favourable rate of return on real estate investment	◦ Amortization period of loan or mortgage	◦ Payback ◦ Internal rate of return (IRR)
Owners and tenants	◦ Affordability ◦ Health and safety, indoor environmental quality, comfort, amenities	◦ Duration of tenancy (tenants) ◦ Duration of mortgage (owners)	◦ Annual rate of rent increases and utility bills (tenants) ◦ Rate of maintenance fee increases and utility bills (owners)
Society*	◦ Ecological footprint ◦ Conservation of land, water, energy resources ◦ Affordability, adequacy, and accessibility ◦ Costs of infrastructure expansion ◦ Durability and resilience ◦ Secure investments promoting equity and sustainability	◦ Life cycle of buildings, cradle-to-grave	◦ Life cycle cost (LCC) using Modified Uniform Present Net Worth (MUPW)**

*Includes owners and tenants, but also includes governments, utilities, and institutions who represent society at large.
**Decision makers are gradually adopting LCC to assess the cost-effectiveness of future-ready buildings. In its simplest form, the life cycle cost is expressed as the NPV of all costs associated with a proposal, which is then compared between alternatives. The lowest LCC usually represents the best investment, provided non-monetary considerations, such as matters related to health, comfort, the environment, and climate action are similar among competing alternatives.

Understanding the diversity of perspectives on housing economics

There are, unsurprisingly, several perspectives to consider when it comes to housing economics.

The *societal perspective* is concerned with the big picture—from adequate housing for all individuals to affordable, sustainable operations. This perspective is longer term, and often bundled with concerns about impacts on the surrounding neighbourhood, city, and region.

Consumer perspectives, or owners and tenants, are primarily concerned with upfront affordability with cost stability (or predictability) long term.

Developer perspectives are more concerned with the market value of housing and its return on investment compared to other investment alternatives. Property owners (landlords, social housing agencies) and housing investors (REITs), are looking for safe and secure long-term returns, while real estate developers are more interested in short term investments that reward risk with attractive rates of return.

Architects must deal with this diversity of perspectives among their clients and balance their design approaches accordingly. However, architects are also a duty-bound regulated profession, with obligations to the public that are longer-term than some other stakeholders.

Cost premiums for future-ready MURBs

The OBC represents *minimum* standards for health, safety, and energy efficiency in buildings. Like all codes, it is slow to evolve and may eventually include requirements for whole life carbon and resilience, but today's future-ready buildings will costs marginally more upfront than buildings constructed to minimum standards.

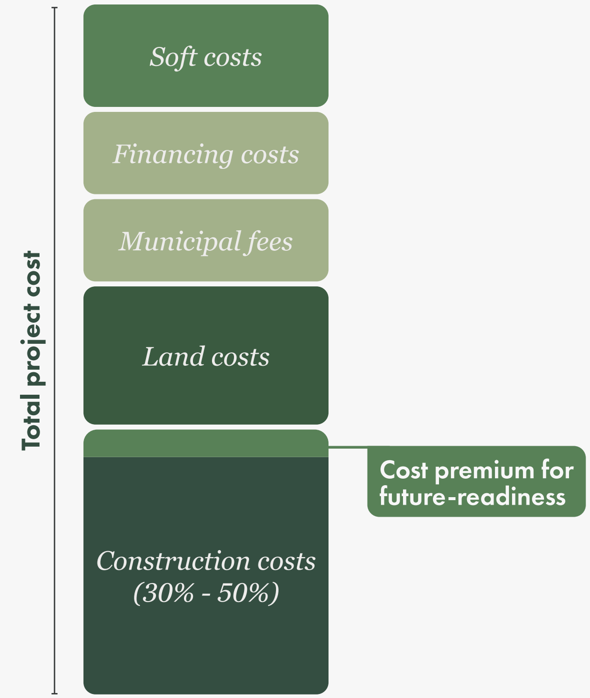
Architects and engineers can, at best, influence construction cost. And while this represents a major component of total project cost, the premium for constructing beyond OBC minimums and making a building future-ready is only a fraction of construction cost, and an even smaller fraction still of total project cost.

The following are typical cost components of a building project:

Construction costs: All costs associated with construction, including materials, labour, and equipment needed to build and commission a new building.

Municipal fees: Including development charges, community needs fees, park fees, and educational development charges, all of which have seen a significant rise across the GGH region.

Land costs: The cost of land is increasingly significant. Demolition of existing buildings and soil remediation add to land costs.



Investing in future-readiness is common sense
The cost premium for building beyond code minimums is, at the high end, 10% of construction cost. Therefore, the total impact may be 3-5%—generally too small to affect affordability or feasibility. But it can make a substantial difference in the energy efficiency, carbon footprint, and resiliency of a MURB.

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Financing costs: Costs associated with borrowing are increasing across the GGH. A critical contributing factor is the amount of time between land acquisition and construction.

Soft costs: These include costs like architectural design fees, legal fees, insurance, and project management.

Total project cost: The sum of all cost components, which varies significantly based on project type, location, size, complexity, and material choices.

Construction costs make up a significant portion of the total building cost, from one-third to one-half, depending on other cost components such as land costs, financing costs, and municipal fees. Across the GGH, these can vary significantly.

It is important to consider that the GGH has experienced dramatic construction cost increases over the past several decades. As a result, the cost premiums associated with future-ready buildings represent only a marginal percentage increase in construction costs. Enhanced energy efficiency levels in recent OBC changes have also narrowed the gap between minimum and future-ready.

Building cheap is expensive

Designing future-ready MURBs within budget allowances can be challenging. Cutting costs for measures that enhance life cycle performance and resilience is risky and costly to future residents, neighbourhoods, and communities. It is far cheaper to invest today than it is to retrofit in the future.

Case studies: real world cost premiums for high-performance and low-carbon

Several recent studies comparing the cost of high-performance MURBs to OBC minimums found only marginal increases in construction cost. But it's important to read these numbers in context.

First, many of those studies predate the latest updates to the building code—so the baseline for comparison has already shifted upward. The gap between minimum code and future-ready is now even narrower. Second, construction cost escalation isn't consistent across all products and systems. Materials and assemblies that support better efficiency and resilience—once considered premium—are increasingly standard. Broader adoption and economies of scale have helped stabilize or even reduce their relative costs.

When all factors are taken into account, the construction cost premium to deliver a future-ready MURB is modest—typically no more than 6.5 to 8.5%, which translates to less than 5% of the total project cost. In a budget dominated by land, fees, and financing, this is a relatively small investment with long-term implications.

The real value proposition architects need to communicate to clients isn't about cost—it's about risk. What are the consequences of designing buildings

$ A MURB that reached the performance specs listed below was estimated to cost a construction premium of 6%.

EUI	100 kWh/m²·yr
TEDI	30 kWh/m²·yr
GHGI	10 $kgCO_{2e}$/m²·yr

Zero Emissions Building Framework. City of Toronto, March 2017.

$ Zero Carbon Buildings (ZCBs) are technologically and financially viable, incurring an 8% construction premium.

Making the Case for Building to Zero Carbon. Canada Green Building Council, March 2017.

$ New MURBs designed as low-carbon-ready have an incremental capital cost range of $0.34 to $1.34 per ft² GFA, which is less than 0.5% of total construction costs in buildings analyzed.

Mechanical System Design Guidelines for Low Carbon Buildings: Voluntary Design Guidelines for Existing and New Buildings. City of Toronto, December 2021.

that aren't resilient to climate shifts, energy volatility, or future regulatory pressures? It's hard to justify passing those risks down to the next generation—especially when the cost of doing better, now, is so comparatively small.

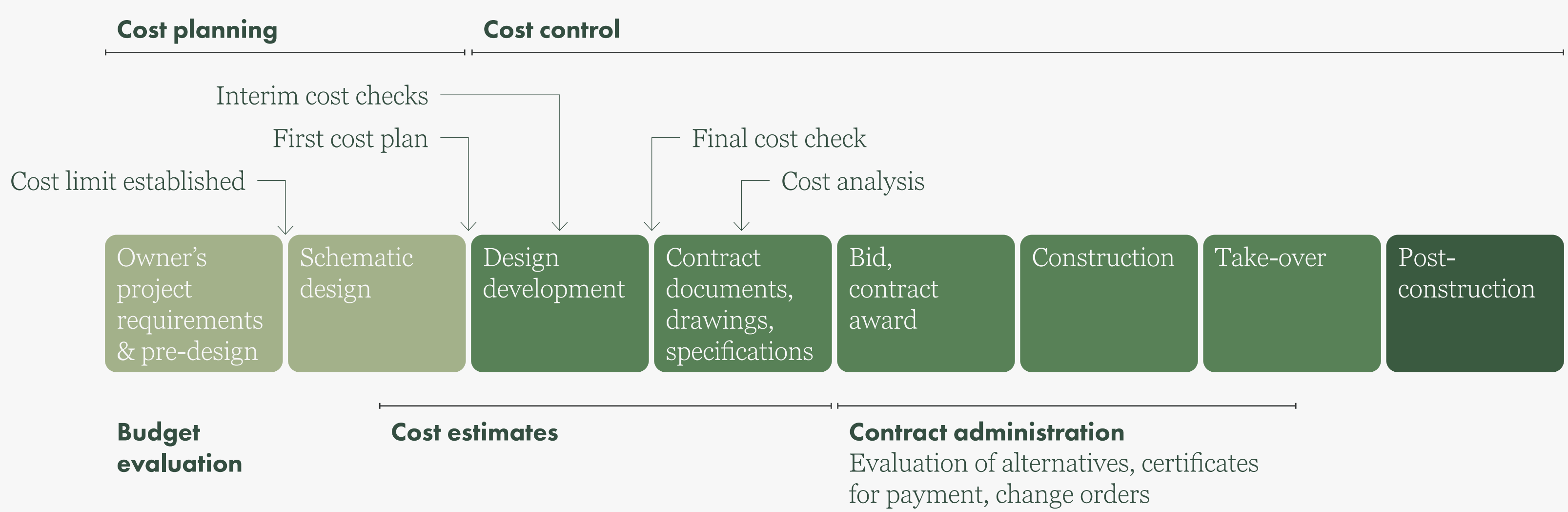
The architect's role

Architects may not set housing policy or shape real estate economics, but they do play a crucial role in influencing the cost-effectiveness of buildings over their entire lifespan.

In an industry that's become somewhat numb to budget overruns and schedule delays, architects are uniquely positioned to help steer projects away from costly pitfalls—especially those that threaten to strip out critical, future-ready measures under the guise of "value engineering."

Cost planning and control starts well before the first sketch. Ideally, it runs in parallel with the development of the Owner's Project Requirements (OPR), setting a cost limit that guides decisions from schematic design through to construction documents.

This process becomes even more important when working with mass timber, where early collaboration with the fabricator and construction manager isn't just helpful—it's essential. Without it, reliable cost planning becomes a guessing game. Design-assist contracts, which bring key players to the table early, are one of the most effective ways to keep projects on budget, particularly for mass timber—but worth considering for any project with tight constraints and high ambitions.



Resilience is an essential design criteria: it ensures habitability during crises and maintains the long-term value of the building.

The best way to manage risk: design for resilience

As our climate continues to shift, so does the range of hazards our buildings need to withstand. Extreme heat, flooding, wildfire smoke, and power outages are no longer rare possibilities—they're becoming regular features of life in the GGH. These events don't just threaten physical buildings; they put lives at risk, disrupt communities, and strain the systems we all rely on.

Investing in resilience—through better envelopes, backup systems, passive strategies, or smarter site planning—often comes with modest upfront costs. But these costs are better understood as a kind of insurance: they safeguard residents, protect building performance during crises, and help maintain long-term asset value.

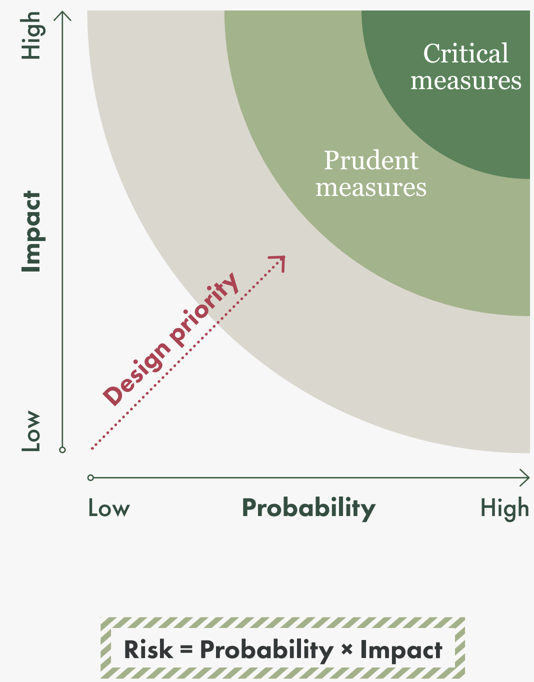
To make smart design decisions, we need to weigh both how likely a hazard is and how serious the consequences could be. If a risk is both probable and high-impact, then resilience measures aren't just nice to have—they're critical. Even low-probability hazards can justify intervention if the consequences are severe enough. This balance of risks and consequences helps teams prioritize what matters most, and where investments will have most impact.

How to evaluate risk

Designing for resilience starts with understanding what could go wrong—and how badly. In the early stages of a project, it's important to identify the kinds of hazards a building might face, how likely they are to occur, and what kind of damage or disruption they could cause. This process of assessing risk (a combination of probability and consequence) helps design teams prioritize which strategies are most worth investing in.

Resilience measures shouldn't just respond to the most extreme events—they should also account for the most likely ones, and the ones that pose the greatest consequences to people's health, safety, and economic security. For example, in the GGH, the risk of major earthquakes may be low, but extreme heat, flash flooding, and power outages are increasingly common—and increasingly dangerous, especially for people living in higher-density housing.

A critical part of this process is understanding that not all hazards are climate-related. Some of the most disruptive risks we face—like blackouts, water supply issues, or overburdened healthcare services—are tied to the resilience of local infrastructure and social systems, not just weather. That's why strong resilience strategies consider both the typical use scenarios of a building (like daily heating, cooling, and circulation), and the exceptional conditions that could compromise it—whether from a 100-year storm or a 10-hour grid failure.



Risk can be prioritized for design
During early stages of design, identify the probability of hazards and the estimated magnitude of their impact to determine priority.

Building resilience that works harder

The good news: most effective resilience strategies do more than one job. A well-detailed building enclosure, for instance, doesn't just reduce operational energy, it can also protect occupants during power outages, shield against both summer heat and winter storms, and provide a first line of defense against high winds, fire, and flying debris. These kinds of multi-benefit solutions are typically more cost-effective than deploying separate fixes for every individual hazard.

Resilience also needs to be considered at multiple scales. The building is only part of the picture. Site design—landscaping, walkways, parking, accessibility—can have just as much impact on how a place performs during extreme events. A poorly drained driveway or an inaccessible entrance can compromise even the most robust envelope.

Strategies fall into two broad categories:

- *Hard measures* are physical: structural upgrades, mechanical backups, envelope detailing, and other infrastructure that helps a building absorb or resist shocks.
- *Soft measures* are behavioural or procedural: fire drills, emergency plans, building-level governance, and occupant education. These don't rely on tech—but they do rely on people being informed and prepared.

Planning for future upgrades

Not every resilience strategy can be implemented right away, but planning for a future upgrade path is a resilience strategy in itself. Buildings can still be designed with migration paths that allow future enhancements to be added over time—without requiring major renovations. For example:

- Roughing in conduit from the roof to the electrical room can make it easier (and cheaper) to add solar panels later.
- Detailing windows to accept future exterior shutters can prepare a building for growing wind risks—without adding the shutters on day one.

This kind of plug-and-play thinking supports a flexible, incremental approach. It gives owners and operators the ability to upgrade as resources allow—without losing momentum. When resilience is built to evolve, we set the stage for long-term adaptability, not just a one-time fix.

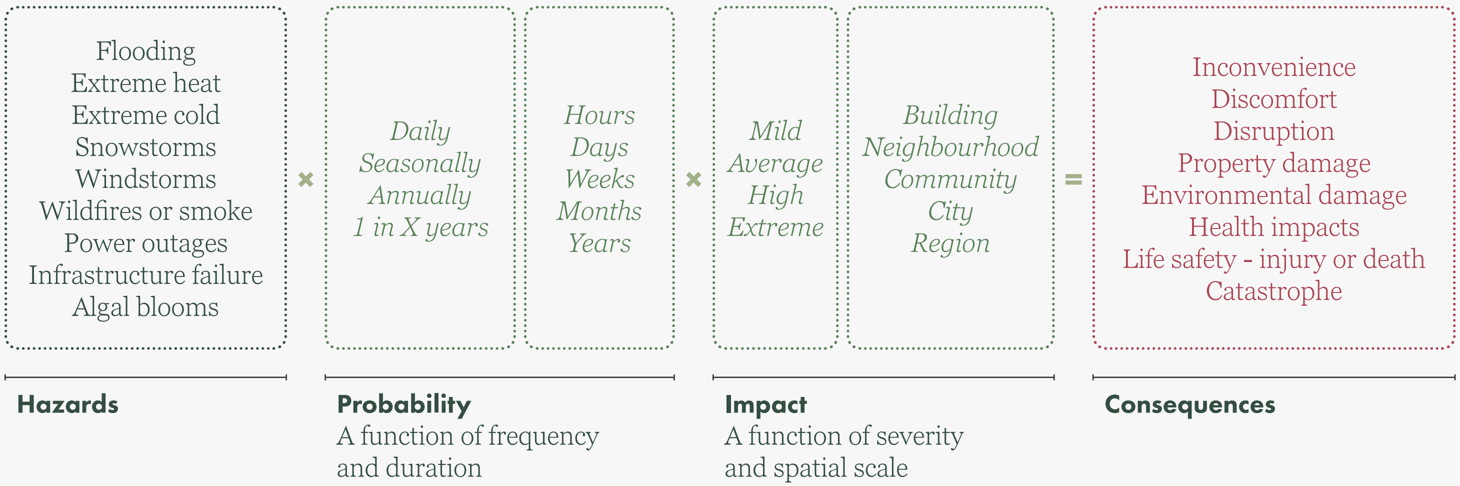
The long-term cost of short-term thinking

Architects have a responsibility not just to design buildings, but to help their clients avoid building the wrong buildings—those that may look affordable on day one but become financial and functional liabilities over time.

In Canada, the legacy of deferred maintenance in social housing is a cautionary tale. Too often, decisions were made based on the lowest upfront cost, without considering the long-term consequences (future-readiness).

> Effective resilience strategies are less expensive than you think, since they tackle multiple threats simultaneously and reduce operating costs.

Risk prioritization



Risks are evolving. Some hazards, like extreme weather, are becoming more important. Take into account the state of local infrastructure as well.

Assessing risk: probability, impact, and consequence
Understanding risk isn't just about identifying hazards—it's about tracing their effects across time and space. This chart outlines a framework for assessing climate and infrastructure-related risks based on three interconnected factors: *probability*, *impact*, and *consequences*.

Each hazard—whether it's extreme heat, flooding, or a prolonged power outage—carries different levels of risk depending on how often it occurs, how long it lasts, and how far its effects extend. A short power outage in a single building may be inconvenient, but a multi-day blackout across a neighbourhood can quickly escalate into a life safety concern. Duration and scale together shape impact.

By mapping this relationship, we can move beyond intuition and begin prioritizing design decisions based on tangible risks. It's not just about what might happen—but when, for how long, and to whom. Resilience is about anticipating the ripple effects—and designing for the people standing in their path.

Recipe for disaster

Canada's aging social housing stock offers a clear warning: when housing is designed to minimize upfront costs rather than maximize long-term value, the consequences are severe—and generational.

For decades, social housing (and market housing) was built under a now-familiar formula:

- Design to legal minimums
- Build for the lowest bid
- Overextend operations
- Offload risk to future generations

In too many cases, design teams were underpaid, construction budgets were razor-thin, and performance standards were treated as optional. The result? Buildings that were uncomfortable to live in, costly to operate, and prone to early failure. Poor detailing, inferior materials, and deferred maintenance practices accelerated deterioration—leaving residents with declining living conditions and future generations with an overwhelming repair bill.

This legacy has left us with buildings that are downcycling faster than they should. But more than that, it's left us with a stark choice: repeat the same mistakes, or shift our thinking.

Future-ready housing can't be built on yesterday's assumptions. It needs to be grounded in *life cycle thinking*—both in terms of *cost* and *carbon*. That means investing in durability, operating efficiency, and occupant wellbeing from day one, and designing buildings that will thrive for generations.

How architects can address risk

A common reason constructors submit costly change claims is the presence of incomplete or inconsistent contract documents. And that's not just a coordination issue, it's often a direct result of inadequate design fees that leave teams without the time or resources to develop thorough documentation.

Architects can reduce this risk by advocating for performance-based specifications that define clear, non-negotiable outcomes—especially when it comes to substitutions.

Constructor pre-qualification is another underused but highly effective tool to ensure that what gets built actually reflects what was designed. With skilled labour shortages already straining the industry, many builders are struggling to staff their sites with experienced workers, making quality assurance, regular inspections, and thoughtful commissioning processes more important than ever. These may add a small premium upfront—but the cost of failure is far greater.

Do this	Don't do this
Design durable, resilient buildings with low operating and maintenance costs	Prioritize short-term capital cost savings at the expensive of durability or future operating costs
Be efficient with materials to reduce the upfront cost and carbon footprint	Over-design or over-specify materials without considering actual needs
Aim for quality and spatial efficiency—smaller, better units are superior to larger, worse ones	Default to bigger units with worse layouts—more space doesn't mean better space
Conduct proper costing during design stages; conduct proper cost control during construction	Skip cost planning or leave costing until after design decisions have already been made
Minimize the potential for contractor claims by ensuring complete drawings and specifications	Leave drawings incomplete or vague—it only invites change orders and disputes later
Use performance-based specifications for materials, components, and assemblies; screen substitutions against these criteria	Use proprietary specs without a clear rationale, and don't approve substitutions without evaluating performance first
Pre-qualify contractors to establish a minimum level of competency and experience	Hire the lowest bidder without confirming their track record
Insist on design assist for projects that require input at early stages of design from manufacturers and construction managers	Delay involving key suppliers or trades if their input could significantly affect coordination or cost
Invoke inspections, quality assurance, and commissioning to ensure conformance to contract documents	Assume conformance will happen on its own—verification and documentation are essential
Provide the building owner with complete documentation to support proper operation and maintenance of their asset	Leave the owner in the dark—operational knowledge is part of the value of good design
Conduct post-occupancy evaluations to gain insights on how to improve design practices	Walk away after occupancy without learning what worked and what didn't

An architect's cheat sheet for housing economics

Architects exercise the most influence in housing economics by designing buildings with good bones. This often means sufficient enforcement of drawings and specifications, a challenging task in an era of high construction costs and price escalation. But, as discussed in this section, we know that cutting quality assurance, design fees, and commissioning only leads to long term burdens.

By adopting a life cycle approach to building design and engaging in best practices throughout each stage of the building process, architects can deliver housing that is a legacy rather than a liability.

Livability

Livability is about designing homes that support real lives, in all their diversity. From light and air to storage and circulation, thoughtful design choices shape how comfortable, functional, and adaptable a home feels.

In the context of smaller units and higher densities, details like room size, layout, and window placement make a big difference. When we design for real people—not just code compliance—we create housing that's truly future-ready.

What is livability?

Livability is one of the most important—and perhaps most overlooked—aspects of multi-unit housing design. It speaks to how well a home supports the lives of the people who live there, day in and day out. While some aspects of livability are tied to where housing is situated—such as access to transit, proximity to jobs, and neighbourhood safety—there's still a lot architects can influence. Thoughtful design can make multi-unit buildings feel like true homes, not temporary accommodations or compromises.

One size doesn't fit all

Livability isn't a one-size-fits-all concept. Different residents have different needs; a young professional in a studio might benefit from access to co-working space and generous bike parking. Older adults might prioritize acoustic privacy, intuitive layouts, and accessibility. Families might place more value on functional kitchens, in-suite storage, and a safe, visible outdoor play area.

These are just a few examples, but they illustrate the importance of thinking beyond a generic unit plan or a boilerplate amenity list. The good news is that developers are already conducting market analyses to assess target residents—architects just need to translate those findings into design choices that align with user needs.

As always, architects should also be thinking about flexibility, since buildings often outlive the residents who occupy them. That might mean thinking about stackable layouts for intergenerational households or convertible amenity rooms.

Persona: young professional

- Secure, easy-to-access bike storage
- Rentable party space
- Co-working lounge
- Well-equipped gym

Persona: older adult

- Quiet and accessible units
- More storage
- Accessible social spaces located nearby
- Emergency response features

Persona: family with kids

- Functional kitchen with lots of storage
- Even more storage
- Visible outdoor play areas
- Bathtubs

Consider this...

We now know that livability should offer more than a fixed checklist of amenities. Some key considerations to guide the livable design of a MURB include:

Design for everyday life: Livability starts in the home—with unit layouts that anticipate furniture and storage that is easy to access. Think about how people live: can two people be in the kitchen at once? Does a unit for families have a bathtub? Is the balcony deep enough to furnish? Is there a front closet for coats? A well-designed home should feel empathetic to its occupants, anticipating their routines and needs across seasons.

Treat common areas as extensions of the home: Shared spaces play a big role in making MURBs feel welcoming and functional. Amenities should be tailored to a specific demographic and adaptable over time. Weigh the importance of amenities such as co-working spaces and social areas depending on the size of units.

Ensure reliable, sufficient functional infrastructure: Waste sorting facilities, bike storage, vertical transportation, and other MURB infrastructure should be reliable and pleasant to use. Consider the changing needs of residents—for example, upright bike storage may not accommodate e-bikes or cargo bikes, which are increasingly common. Dignify stairs up to the second or third floor, where residents may be more likely to use them.

Think about serviceability: Provide window treatments when possible or allow residents, including tenants, to easily install their own. User serviceable components, such as light fixtures or air filters, should be easy to replace without requiring special tools or parts. Anticipate how residents might personalize a space and design for it; for example, protect vapour barriers and other critical systems from penetrations caused by hanging pictures.

Think about the landscape: Housing doesn't exist in a vacuum. MURBs affect the neighbourhoods they're a part of, and vice versa. Designing with livability in mind also means considering how the building contributes to the surrounding community. That can include landscaping, walkability, and even offering mixed-use ground floors.

Accessibility and aging-in-place: Buildings last a long time—usually more than a lifetime—and should be expected to serve a wide range of individuals, including those with disabilities. Residents should also have the option to stay in their units as they age, the same way we may expect a single family dwelling to accommodate aging homeowners. Provide accessible units that meet universal design criteria and design other units with future retrofits in mind. Accommodating aging or disability shouldn't require an impractical overhaul of the unit.

Finally, resilience is a part of livability. While everyday comfort is critical, buildings must also function during extreme conditions—heat waves, ice storms, power outages. A future-ready MURB isn't just livable on a good day; it supports its residents when things go wrong, too.

> The OBC establishes minimum standards, but these often fall short of supporting livable, long-term housing. While compliance is necessary, architects have a responsibility to design beyond the minimum. Ask yourself, *would I live here?*

How small is too small?

Across Canada—and particularly in rapidly growing regions like the GGH—apartment sizes are decreasing. The challenge we face is not only how to accommodate more residents within smaller footprints, but how to do so while improving overall quality of life. Architects are increasingly called upon to deliver high standards of livability, even as available floor area per person continues to decline.

Suite design plays a critical role in supporting livable housing. Unit size, ceiling height, window area, access to private or semi-private outdoor space, and storage capacity all influence how a home is experienced. These considerations are especially important in a multicultural and diverse society—where conventional assumptions about household structure, mobility, and daily use may not apply.

Experience—and recent market trends—suggest that poorly laid-out units with limited daylight, inadequate storage, and cramped conditions are becoming less desirable. Even when they technically meet OBC requirements, they may fall short of what is needed to support dignified, long-term residency.

Minimum room areas, window areas, and dimensions

Per OBC 9.5, 2024

Room or space	Room area	Window area	Floor-to-ceiling height
Living areas, separate or combined with other areas	13.5 m^2 (145.3 ft^2)	10 % of area served	2300 mm over >75% of the required floor area with a clear height of 2100 mm at any point over the required area
Living space combined with dining and kitchen in one-bedroom unit	11.0 m^2 (118.4ft^2)		
Dining room	7.0 m^2 (75.4 ft^2)		
Dining space in combination with other spaces	3.3 m^2 (35.5 ft^2)		
Kitchen space, separate or combined with other spaces	4.2 m^2 (45.2 ft^2)		
Kitchen space in one-bedroom unit	3.7 m^2 (39.8 ft^2)		
Primary bedroom (without built-ins)	9.8 m^2 (105.5 ft^2)	5 % of area served	2300 mm over >50% of the required floor area or 2100 mm over 100% of the required area Any part of the floor having a clear height of less than 1400 mm shall not be considered in computing the required floor area
Primary bedroom (with built-ins)	8.8 m^2 (94.7 ft^2)		
Other bedrooms (without built-ins)	7.0 m^2 (75.4 ft^2)		
Other bedrooms (with built-ins)	6.0 m^2 (64.6 ft^2)		
Bedroom spaces in combination with other spaces	4.2 m^2 (45.2 ft^2)		
Bathroom, laundry	Sufficient space for sink, toilet, and shower or bath	None required	2100 mm in any area where a person would normally stand
Passage, hall, vestibule (width)	860 mm (2'-10")	None required	2100 mm
Public/exit corridor (width)	1100 mm (3'-7")	None required	2100 mm

Minimum window areas typically result in WWRs around 15%.

Beyond minimums

While the OBC sets baseline requirements, these minimums are often insufficient to ensure high-quality housing. For example, the Code permits studio units without balconies, allows bedroom spaces without dedicated windows, and establishes minimum window areas that often result in window-to-wall ratios of just 15%—well below recommended thresholds for natural daylighting and ventilation (30-40%). It also contains no minimum total suite area requirements.

In this context, architects have a critical role to play. While working within regulatory constraints, they can also advocate for higher internal design standards, informed by lived experience, building performance evidence, and evolving household needs. In particular, careful attention to spatial quality, room proportions, window placement, and ceiling heights can significantly enhance livability, even in modestly sized units.

Click here to view resources related to housing design guidelines, including the size of suites.

Minimum room areas, window areas, and dimensions

Per *Apartment Typology Booklet*, the Land Development Agency, Dublin, Ireland, 2023

Room or space	Studio 1-2 people	1 Bedroom 2 people	2 Bedroom 3 people	2 Bedroom 4 people	3 Bedroom 5 people
Living, kitchen, dining	30.0 m^2	23.0 m^2	28.0 m^2	30.0 m^2	34 m^2
Primary bedroom		11.4 m^2		11.4 m^2	11.4 m^2
Twin bedroom			13.0 m^2	13.0 m^2	13.0 m^2
Single bedroom			7.1 m^2		7.1 m^2
Storage	3.0 m^2	3.0 m^2	5.0 m^2	6.0 m^2	9.0 m^2
Entire apartment	37.0 m^2	45.0 m^2	63.0 m^2	73.0 m^2	90.0 m^2
WWR			35% WWR		
Balcony	4.0 m^2	5.0 m^2	6.0 m^2	7.0 m^2	9.0 m^2
Floor-to-ceiling height			2.5 m		

Unit mix, size, and location

Per *The Affordable Rental Housing Design Guidelines*, City of Toronto Affordable Housing Office, 2015

Type of unit	Share of MURB	Minimum unit area	Average unit area
Bachelor	None allowed		
One bedroom	40% of all units	48.7 m^2 (525 ft^2)	55.0 m^2 (590 ft^2)
Two bedroom	40% of all units	60.0 m^2 (650 ft^2)	67.4 m^2 (725 ft^2)
Three bedroom	15% of all units	84.0 m^2 (900 ft^2)	93.0 m^2 (1000 ft^2)
Four bedroom	5% of all units	102.0 m^2 (1100 ft^2)	109.0 m^2 (1175 ft^2)

Bedrooms should be a minimum of 9.3 m^2 (100 ft^2) with a minimum dimension of 2.7 m (9 ft) and include operable windows to the exterior.

Family units are preferred on the ground floor with access to the street and outdoor space, or in buildings that cannot permit this configuration, family units can function well on a podium with an outdoor terrace. Family units should have larger living, dining, and storage areas, as well as private outdoor space (such as balconies, terraces, patios).

Learning from the guidelines

Current guidelines, such as the City of Toronto guideline on the previous page, go beyond minimum Code requirements without veering into excess. But there's still work to be done—particularly when it comes to supporting a wider range of households, including multi-generational families, group living, aging-in-place, and supportive housing models. Just as critical is the need to make universal design (UD) the norm, rather than the exception. Everyone should be able to safely and comfortably enjoy their home, regardless of age or ability—without needing costly renovations as their needs evolve.

If we look to Ireland, a country with similar climates and cultural values, for comparison, apartment design standards offer some compelling bench-marks. Their guidelines mandate private balconies and minimum window-to-wall ratios that support daylight access and occupant wellbeing. Ceiling heights are also slightly higher than what's required under the Ontario Building Code.

Sufficiency: efficiency without compromise

Recent European thinking has embraced the idea of "sufficiency" in housing—prioritizing well-being over maximized density. Irish standards reflect this approach: while they sit toward the lower end of the typical floor area per person range (15 m² to 55 m²), they still result in apartments that feel more generous than many units currently being built in GGH condominiums.

Recently, the market has been telling architects and developers that buildings designed to minimum size requirements are not desirable. Sufficiency proposes a right-sized approach that balances sustainability and livability.

Core housing needs

According to the CMHC, households are considered to be in *core housing need* if their current home costs more than 30% of pre-tax income, is inadequate or unsuitable (such as being too small or requiring major repairs), and they can't afford alternative housing in their community.

As of the 2021 Census, 10.1% of Canadian households—roughly 1.5 million—were living in core housing need. With rising costs of living, including increasing rents and mortgage rates, this number is likely to grow. Designing for longevity, durability, and ease of maintenance helps keep residents safe in stable homes over the long term.

So, what is the *right* size?
The right size is the sustainable size. Recent studies based on ecological carrying capacity indicate a sufficiency range of between 10 m² and 35 m² per person of living space. Current OBC minimums fall towards the low end of the sufficient range, suggesting that dwellings can afford to be larger without compromising sustainability.

	Cramped	Sufficient	Partially Sufficient	Not Sufficient	Unsustainable
Living space per person	0	10 m² (108 ft²)	35 m² (377 ft²)	45 m² (484 ft²)	60 m²+ (646 ft²)
GFA per person	0	15 m² (161 ft²)	55 m² (592 ft²)	70 m² (753 ft²)	95 m²+ (1022 ft²)

Outdoor spaces are essential rooms that shape daily life, and their success depends on intentional design for comfort, inclusivity, and durability.

Balconies: the connective tissue of MURBs

Balconies are more than just architectural features. They connect the private domestic realm with the shared public realm, offering residents access to fresh air, light, and informal social connection without leaving home. They're not just outdoor amenities; they're spaces where the personal meets the public, and where broader questions of equity, inclusion, and agency can quietly play out.

While balconies are optional in the building code, they play an outsized role in livability—especially for residents who can't easily access shared amenities like courtyards or parks. For many, a balcony is their only piece of outdoor space, and its design can significantly impact quality of life.

Around the world, designers are rethinking balconies as adaptable, flexible extensions of living space—places that support gardening, caregiving, working from home, or simply doing nothing at all.

Designing better balconies

To design better balconies, practitioners must treat them not as nice-to-haves, but as essential outdoor rooms: spaces for retreat, for comfort, and for casual connection. They should be sized to comfortably accommodate seating and a table suited to the number of occupants in the suite, oriented for light and air, and detailed with privacy, shading, and wind mitigation in mind. Plantings and privacy screens may also be incorporated to reflect personal and cultural preferences.

Start by placing balconies intentionally—connected to living areas, with attention to views and neighbouring balconies to avoid privacy conflicts.

Importantly, balconies shouldn't just be measured by how they look or what they cost to build, but by how they're used and valued by the people who live with them. Post-occupancy evaluations can help architects understand how balconies support health, dignity, and connection. After all, the best balconies don't just extend a unit's square footage—they extend its possibilities.

Terraces and rooftops

Terraces and rooftops provide opportunities for shared outdoor space at a larger scale. Terraces are generally accessible directly from suites or corridors at the same level, though in some cases they may be assigned to a single unit. Rooftops are usually shared spaces reached by stair or elevator, but seldom occupy the entire roof since equipment, photovoltaic panels, and mechanical penthouses often compete for space.

Unlike balconies, terraces and rooftops are inherently collective. They must accommodate the needs of all residents, including children, older adults, and people with disabilities. This requires careful design of plantings, furnishings, and amenities such as canopies for shade and shelter, as well as windscreens that become more critical as height increases. Durability, maintenance, cleaning, and snow removal must all be considered to ensure long-term usability.

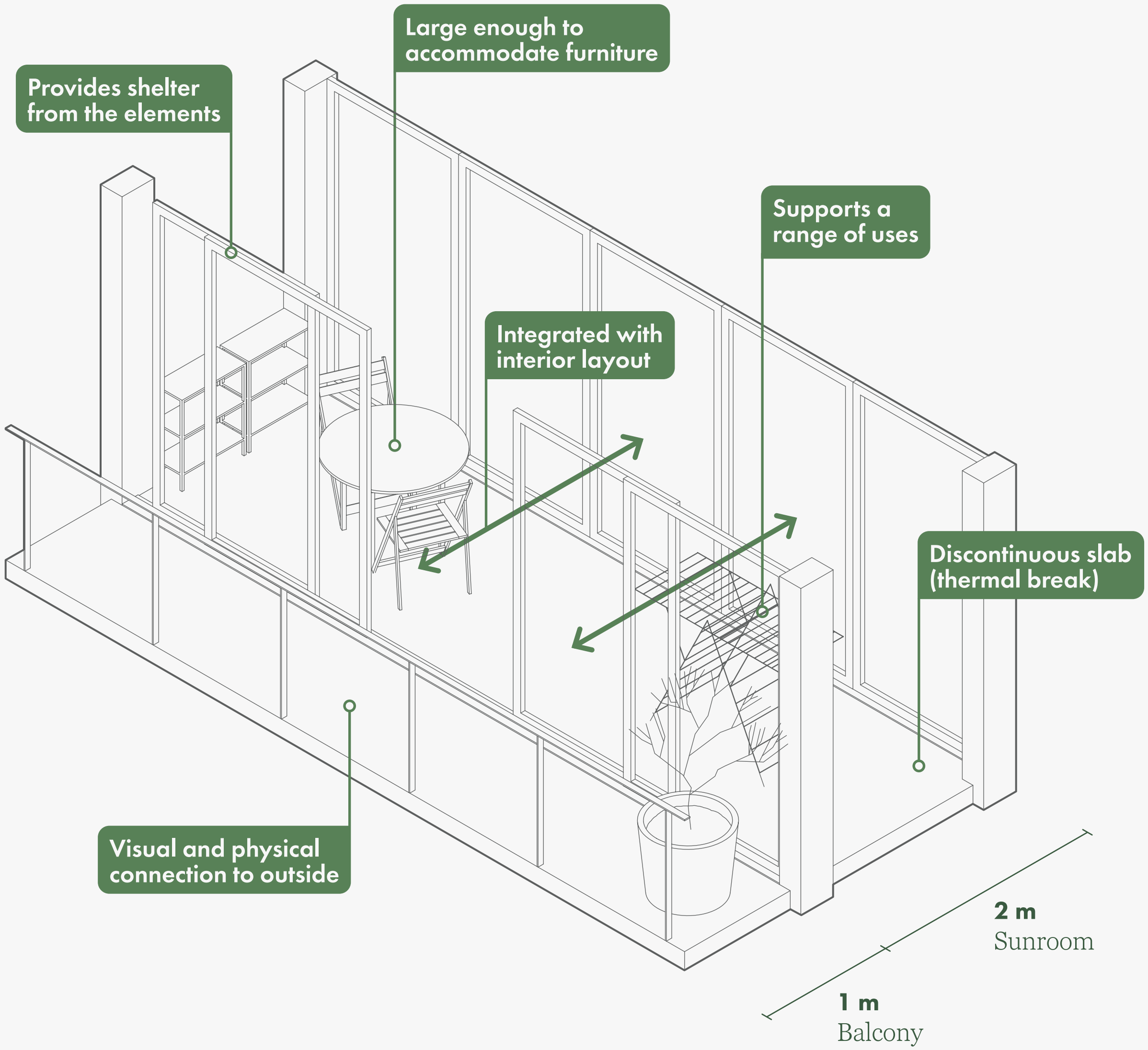
Because they are larger, horizontal surfaces, terraces and rooftops also carry greater technical demands. They represent a higher risk of water leakage and moisture penetration than balconies, making effective drainage and moisture management critical. Surface treatments should be safe, durable, and easy to clean, and designers should also explore measures that discourage birds and rodents from inhabiting these spaces.

Balconies in context

Balconies, terraces, and rooftops together create a spectrum of outdoor rooms that mediate between private and public life. They occupy a kind of regulatory grey zone: not fully addressed in planning frameworks (public realm) and only lightly covered by building codes (domestic realm). Their quality depends less on regulation and more on design intention—an opportunity for architects to deliver spaces that profoundly shape everyday livability.

Click here to view resources on the design of balconies, terraces, and rooftops.

Balcony case study: Tour Bois-le-Prêtre



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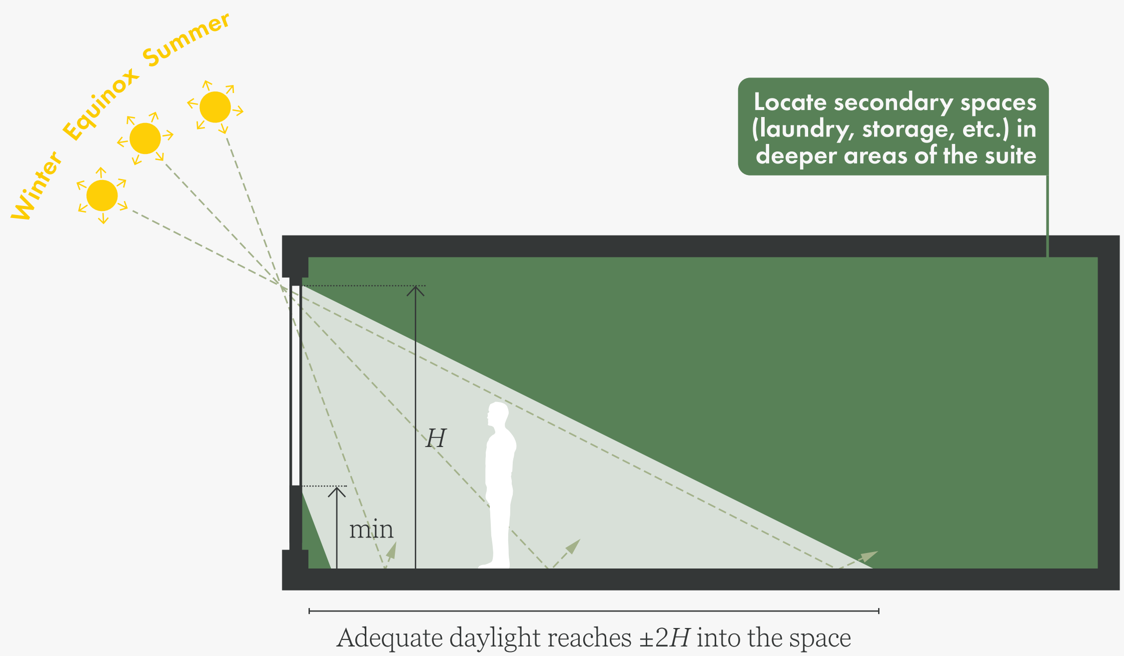


Deep spaces are dark spaces

A good rule of thumb for the zone of adequate daylight penetration is twice the height of the window. Glazing below 0.9 m (3 ft) does not contribute to daylighting. Remember, interior suite finishes also play a role in providing reflected light.

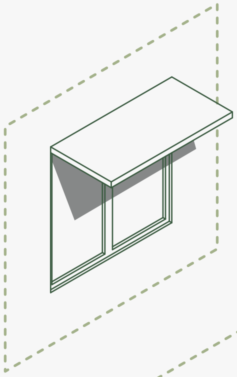
Designing for adequate daylighting

Getting enough daylight into multi-unit buildings can be challenging. A lot of MURBs, especially in built-up areas, are sited according to priorities other than solar orientation. Most suites only have windows on one side (*single aspect*), and if the floorplate is deep, daylight does not penetrate far enough to provide comfort and livability benefits.

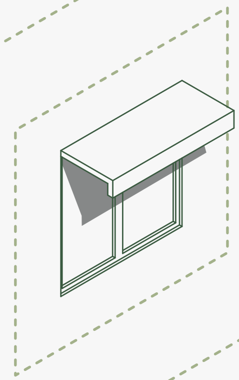
After orientation and building form have been established, strategize daylighting of every main room (living, dining, kitchen, and bedroom). When considering window size, note that window height is more impactful for daylight than window width.

Ideally, operable windows are provided to every main room; but where this is not possible, ensure adequate daylight is provided to rooms that are normally occupied during the day.

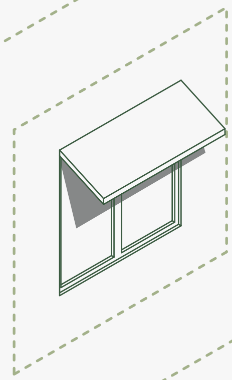
> Daylight penetration is mainly influenced by the height of windows and the depth of spaces.



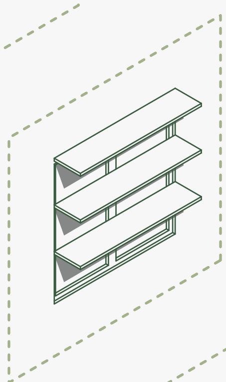
Baseline shading device
A simple horizontal projection



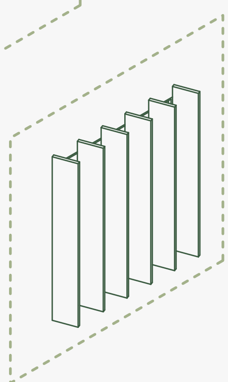
Shading device with lip
Dropping the leading edge of the shade reduces depth



Angled shading device
A downward angled shade reduces depth



Segmented shading device
Breaking up a shade into louvres reduces depth



Vertical shading device
Good for east and *especially* west facades

> ⚠ To avoid shading devices being "value engineered" out, conduct a thorough cost analysis of cooling equipment and operating costs—they typically pay for themselves.

Overheating, glare, and privacy

Once an adequate daylighting strategy has been designed, it is equally important to control against glare and overheating. External shading devices are effective passive tools for reducing solar heat gains, and can be designed with seasonal sun angles in mind, such as those that allow deep sun penetration in the winter while curbing high-angle summer sun. This is an essential tool for energy efficiency.

Shades, blinds, and other internal window treatments are less effective for reducing solar heat gain but allow residents to control privacy—an important factor in livability. These treatments should be provided with new housing when possible; otherwise, ensure that walls and ceilings adjacent to windows will allow for easy installation in the future.

While climate change is often associated with overheating, it should also be noted airborne projectiles are becoming increasingly common with severe storms. Adjustable external shutters or louvres are gaining popularity as an approach which combines shading, privacy, and window protection.

Livability gut check

☐ **Integrated accessibility**	Are there accessible units? What about common spaces, amenities, and outdoor areas? It may be prudent to hire an accessibility consultant to better design for universality.
☐ **Relevant amenities**	What's your neighbourhood and who's your audience? Consider, for example, providing co-working spaces if units are too small for offices. Provide relevant amenities in spaces that are flexible enough to be adapted to future uses.
☐ **Usable balconies**	Are the balconies usable? Are they sufficiently sized for furniture and appropriately located for access, shading, wind, and privacy? Are they thermally broken from the rest of the floor system?
☐ **Convenient and sufficient storage**	Is there enough storage for practical, long term living? Is that storage located appropriately in key areas like the kitchen, front entry, bathroom, and bedrooms? If built-in storage is not possible, consider providing nooks or niches that can support resident storage furniture, like wardrobes.
☐ **Convenient waste sorting**	Providing easy to use waste sorting is a major factor in waste sorting compliance. These spaces should be resilient, easy to clean, and negatively ventilated where possible.
☐ **Daylight control**	Units should come with shading devices and window treatments for heat control, glare, and privacy. Where interior window treatments are not available, provide adjacent surfaces that can enable easy installation of shades and blinds by the tenant.
☐ **Diverse bike parking**	While vertical bike racks are compact, not all bikes can be stored in these systems—bikes with fenders, electric bikes, and cargo bikes (increasingly common in cities) are often not compatible. Provide at least some proportion of horizontal bike racks, including some with proximity to electrical outlets.
☐ **Safety and security**	Are there blind spots, dark areas, or hidden nooks that might not always feel safe? How is building access delegated—and how easy is it for residents to let in guests?
☐ **Serviceability**	Identify components, fixtures, or filters that are user-replaceable consumables. Are they easily replaceable by the tenant or building superintendent? Are replacements easily found? Note that most household LED fixtures today are not serviceable and require the entire fixture to be disposed of.
☐ **Vertical transportation**	Is there sufficient vertical transportation to support rush hour traffic and provide reasonable service during outages or emergencies? Consider providing dignified stairs for lower storeys to provide relief to elevators.

Click here to view resources for enhancing the livability of MURBs.

Stewardship

Stewardship means more than preserving the buildings we design—it's about cultivating knowledge, responsibility, and care across generations.

As the impacts of climate change intensify, the role of the architect is evolving—from creator to caretaker. This section explores how we can steward not just buildings, but the profession itself: by sharing knowledge, advocating for intergenerational equity, and designing housing as a cultural resource rather than a commodity.

Buildings and people need stewardship

Stewardship is one of those quietly powerful ideas. It's about the ethical and responsible care of people, places, systems, and resources—natural, built, and economic. In architecture, it means recognizing that housing is more than a line item or an asset class. It's a cultural resource and a foundation for daily life.

Stewardship also means caring for the profession itself. That includes mentoring interns and students, sharing knowledge, and creating a culture where architectural practice is future-ready—not just in tools and technologies, but in values. If architecture is going to help build a better world, it has to support the people who shape it.

Buildings can't take care of themselves. They need attention, maintenance, and thoughtful upgrades over time. But the people who look after buildings—the stewards—need care too. They need training, community, and access to resources so they can respond to today's challenges and tomorrow's uncertainties.

This section of the guide explores stewardship in the context of MURBs: how we care for buildings, how we support the people who do that work, and how this ethic ties into long-term sustainability. For a long time, stewardship sat in the background of sustainability conversations. That's changing.

A brief and incomplete history of environmental stewardship

Many trace the roots of the modern environmental movement to Rachel Carson's *Silent Spring* (1962), which exposed the dangers of pesticide use and shifted public awareness. Around the same time, architect Michael Reynolds began building *Earthships* in the New Mexico desert—off-grid homes made with recycled materials, thermal mass, and passive systems for heating, cooling, and food production. They were strange, radical, and early examples of what would evolve into today's green building movements.

By the 1970s, the global energy crisis—sparked by oil shortages and political instability—pushed energy conservation into public consciousness. In Canada, this led to the development of the R-2000 program; in Germany, to the creation of Passivhaus. Both reflected a growing appetite for buildings that used fewer resources and gave more back.

Around the same time, a group of global thinkers known as the Club of Rome released *The Limits to Growth* (1972), warning of the consequences of unchecked development. In 1987, the *Montreal Protocol* successfully coordinated international action to protect the ozone layer—proof that cooperation could work. That same year, the *Brundtland Report* helped mainstream the idea of sustainable development, framing environment and economy as interdependent.

The language of climate change became public in 1988 when NASA scientist James Hansen testified before the U.S. Senate. That year also saw the founding of the Intergovernmental Panel on Climate Change (IPCC), tasked with assessing climate science and shaping global response.

Throughout the 1990s and 2000s, more tools emerged to help quantify our impact. The ecological footprint, developed at UBC, gave us a stark visual of how much nature our lifestyles require. International climate conferences gained momentum, leading to key agreements like the Kyoto Protocol (1997) and the Paris Agreement (2015).

In the architecture world, green building certification systems became widespread. But over time, energy efficiency alone came to feel insufficient. The focus has since shifted to *whole life carbon*—the emissions tied not just to building operations, but also to material production, construction, and eventual demolition. Understanding this full picture is essential for meeting net-zero goals.

More recently, the concept of sufficiency has added a new layer. Instead of asking how to make more with less, it asks: how much is enough? In building terms, that means right-sizing, reducing material use, and focusing on wellbeing within ecological limits.

Across all of these shifts, one thing has become clear: sustainability isn't just a technical challenge—it's an ethical one. And that brings us back to stewardship. Lasting change will depend not only on design and policy, but on a deeper shift in values. Buildings, like ecosystems, require long-term care. So do the people and systems that support them.

Climate change conference meets in Kyoto, 1997 - *UN Photo/Frank Leather*

Beyond growth: rethinking progress

Living within the planet's ecological limits means recognizing the difference between growth and development. Growth usually means more—more people, more consumption, more waste. Development, on the other hand, doesn't have to increase our footprint. We can develop new medicines, technologies, art, and systems of care without using more resources. In fact, meaningful development often improves quality of life precisely by doing less harm.

The Brundtland Report (*Our Common Future*, 1987) framed sustainable development as:

> *Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.*
>
> — Brundtland, G.H. (1987). *Our Common Future: Report of the World Commission on Environment and Development.*

It's a definition rooted in intergenerational equity. It acknowledges limits—not fixed boundaries, but the real constraints of technology, governance, and the planet's ability to absorb human activity.

Since then, frameworks like *post-growth* or *beyond growth* have gained traction, especially in the global North. They suggest that true prosperity doesn't require endless expansion—it requires balance. That might mean reducing consumption, shifting how we measure success, and designing systems that prioritize wellbeing over profit. In this light, housing becomes a central tool—not just shelter, but a platform for health, equity, and climate resilience.

In 2015, the United Nations adopted the *2030 Agenda for Sustainable Development* and its 17 Sustainable Development Goals (SDGs). These goals link poverty, health, education, equity, and climate action into a single, interdependent framework. Housing plays a role across many of them. Yet here in Canada, too many people live in inadequate housing—or have no housing at all.

The SDGs emphasize inclusion and the idea that *no one gets left behind*. For housing, this means acknowledging the gaps in our current systems: who is excluded, who is most vulnerable, and how we might design a future where housing meets real needs—not just market demand.

United Nations Sustainable Development Goals (SDGs) - Architects engaged in the design of future-ready multi-unit residential buildings are addressing a number of SDGs: 3. Good Health and Well-Being; 11. Sustainable Cities and Communities; 12. Responsible Consumption and Production; and 13. Climate Action.

Sufficiency: doing less, better

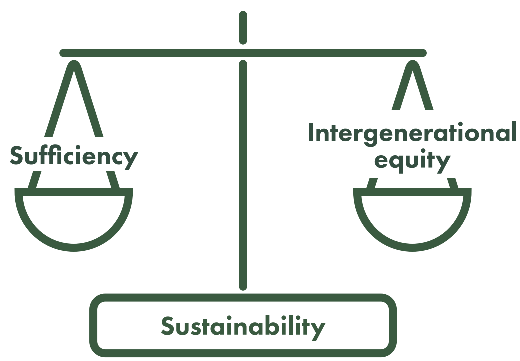
The word "sustainability" can be a bit loaded. For some, it evokes the idea of propping up a lifestyle in the global North that's already chewing through far more than its fair share of the planet's resources. In that context, just sustaining what we have isn't enough. What we really need is a rebalancing—a shift toward *sufficiency*.

Sufficiency has been gaining ground in sustainability conversations, especially in the face of evidence that efficiency gains and green tech alone won't get us to where we need to be. At its heart, sufficiency is about doing less, but doing it better. It means adjusting not just how we build, but how we live—rethinking our values, our consumption patterns, and our collective expectations of what "the good life" looks like.

But sufficiency can't stand on its own, either. It has to be paired with intergenerational equity. Without that, we risk leaving future generations locked into systems—technological, economic, and social—that narrow their choices and increase their burdens. True sustainability requires that we ask not only what's enough for us, but what will be left for them.

The Intergovernmental Panel on Climate Change (IPCC) now explicitly names sufficiency as a critical strategy to meet climate targets. They define it as "a set of policy measures and daily practices that avoid the demand for energy, materials, land, water, and other natural resources while providing wellbeing for all within the planetary boundaries." In other words: use less, share more, and make it count.

Sufficiency plays out at different scales. On a personal level, it might look like downshifting, simplifying, or being more intentional about how and where we live. Collectively, it calls for bigger changes: rethinking the growth-at-all-costs mentality, reimagining success beyond accumulation, and rebuilding systems that support equity over excess. It's about recognizing limits—not as a burden, but as a way to ensure that everyone gets a fair shot at a good life.



Housing at the balance point - Sustainable development must meet the needs of the present and the future. But the normative housing expectations of Canadians make it very challenging to strike a balance. Home ownership is a deeply embedded expectation that obscures the need to establish housing as a basic right.

Stewardship and authorship

Stewardship doesn't begin and end with buildings—it's just as much about the way we share ideas. In European architecture traditions, much of the discourse has revolved around authorship and intellectual property. Architects still hold copyright over their designs, unlike the scientific community where open collaboration and shared knowledge have long been standard practice.

But if we're serious about long-term thinking, we have a lot to learn from other traditions. Many Indigenous communities across Canada have cultivated ways of sharing knowledge that are fundamentally different from the Western emphasis on ownership. These practices are rooted in deep respect for place, community, and interdependence—and they carry enormous relevance for anyone working in housing today.

Indigenous knowledge sharing is more than just passing along information. It's relational. It honours protocol, community context, and the integrity of lived experience. Done right, it can support reconciliation, guide environmental stewardship, and inform more culturally responsive housing policies.

One teaching that offers a powerful lens for design is the Seventh Generation Principle, rooted in Haudenosaunee philosophy. While you may be familiar with the most recent interpretation—"in every deliberation, we must consider the impact on the seventh generation"—the idea itself reflects a longstanding ethic of long-term responsibility. Decisions made today should support the wellbeing of those yet to come—seven generations from now. It's a call to think beyond short-term gain and to act as the stewards of a future we may never see.

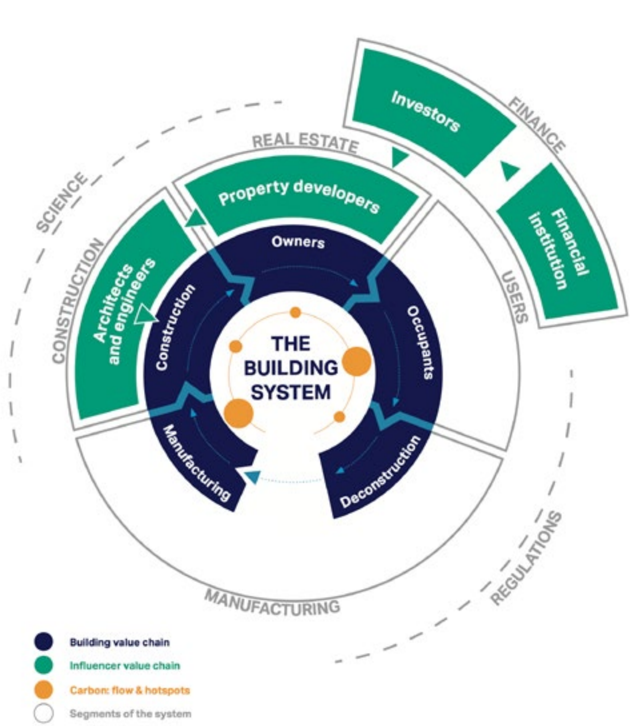
In practice, it challenges us to design housing with long horizons in mind—homes that can serve for 100 years or more, with enough flexibility to adapt to changing needs over time. Durable, adaptable, serviceable: buildings that don't just meet today's needs, but quietly anticipate the ones to come.

Designing for the long game

Sustainable housing isn't just about energy performance or high-efficiency gadgets. A strong sustainability framework balances multiple priorities: resource efficiency, environmental protection, social equity, and long-term affordability. None of these elements exist in isolation—what matters is how they work together.

Getting there takes cooperation. Future-ready housing depends on a shift in mindset from treating buildings as short-term financial instruments to valuing them as cultural resources—designed to last, evolve, and serve multiple generations. That means thinking in life cycles, not sales cycles.

The diagram below shows something interesting: most carbon hotspots in a building's life span are concentrated around manufacturing and occupancy. These are precisely the points where architects and engineers have the most influence. By choosing lower-carbon materials and designing for the "three Ls" (long life, loose fit, low impact) we can reduce both embodied and operational emissions over time. It's about better choices—and earlier ones.



Even in the face of policy setbacks, there's reason for optimism. We now have ample evidence that smart, climate-conscious design can deliver resilient housing with minimal added cost. The challenge isn't technical—it's cultural. Architects will need to lead the conversation, helping clients and the public see beyond surface trends.

> *"...the influencer value chain plays a crucial role in the very early stages of buildings... their decisions have a significant impact on the future emissions of buildings."*
>
> — *World Business Council for Sustainable Development*. (2020). The Building System Carbon Framework. Geneva, Switzerland.

The Building System - This framework highlights the major opportunities for addressing the reduction of our carbon footprint within the system of the building industry. Architects and engineers are major influencers who have the potential to impact all stakeholders.

What architects can do right now

There's no shortage of forces shaping housing in the GGH—many of them well beyond the architect's control. Economics, politics, planning policy, and developer expectations all set the boundaries within which architects operate. And while architects are citizens like anyone else, their formal role in shaping housing is still largely limited to the buildings themselves.

But that doesn't mean architects are powerless. Far from it.

The profession has an important stewardship role to play—one that extends beyond individual projects. Professional associations can advocate for policy shifts that reflect climate realities, housing equity, and long-term thinking. They can push for accreditation standards and continuing education that align with the challenges we're facing, from embodied carbon to accessibility to housing precarity. And they can help raise the floor on practice by promoting competence and accountability across the field.

At the practice level, future-readiness starts with culture. Individual firms have the agency to adopt internal standards that go beyond code minimums to prioritize lifecycle thinking, social inclusion, climate resilience, and thoughtful design, even when those things aren't explicitly required. That might look like office-wide templates for massing studies that assess solar access and passive design. Or project kickoff meetings that include discussions about embodied carbon targets and tenant wellbeing—not just budgets and timelines.

Architects also have a critical role to play outside the office. Teaching, mentoring, and speaking to the public about the importance of design all help to cultivate a broader understanding of architecture's value. These are quiet but powerful ways to shift the culture of housing—to ensure the next generation of designers is better equipped, and the public more invested in the role of architecture in everyday life.

Future-ready housing won't be delivered by architects alone. But it can't be delivered without them either. The influence of design—especially early, thoughtful design—is too important to be left out of the conversation. And with great influence comes great responsibility.

A short checklist for stewardship in architectural practice:

- *Embrace your influence:* Acknowledge the responsibility that comes with your influence, especially in the early design stages, to create thoughtful and resilient housing.
- *Educate and mentor:* Share your knowledge with the next generation of designers and the public to raise awareness about the value of good design.
- *Shape the conversation:* use your professional associations to advocate for policy changes that address climate realities, housing equity, and long-term thinking.
- *Go beyond the minimum:* Set internal standards within your firm that exceed code requirements and prioritize life-cycle thinking and social inclusion.

Click here to view resources for the stewardship of the natural and built environments.

Looking to the future of practice (at the Toronto Society of Architects and beyond)

The TSA has long recognized that stewardship is central to architectural practice—not just as a technical responsibility, but as an ethical one. Through public programming, advocacy, mentorship, and continuing education, the TSA supports a culture where architects are seen not just as designers, but as caretakers of the built environment.

Part of that work involves recognizing the full arc of a building's life. Architects have traditionally been involved only at the front end—concept, design, documentation. But future-ready practice requires more than just being the "procreators" of buildings. It means stepping into a more complete role: one that includes building, commissioning, operating, maintaining, and renewing what we create—not just making buildings, but raising them well.

This expanded view of practice asks us to shift focus. Not toward originality or spectacle, but toward long-term usefulness. Toward cultivation, conservation, and regeneration. Toward systems that reduce harm and promote social and ecological equity. Architects have a choice: to be authors of objects, or stewards of environments that support life. That choice begins with how we educate, train, and support practitioners throughout their careers.

Stewardship also demands we take knowledge seriously—not just as something to possess, but as something to share. Of all human-made resources, knowledge is the most naturally circular. When shared well, it becomes a regenerative force—fuel for collective intelligence, not individual ownership. History reminds us that when knowledge is hoarded or lost, progress stalls. A sustainable profession depends on the open flow of ideas across time, disciplines, and generations.

That is, in part, what this guide seeks to accomplish. It's a contribution to the profession's collective knowledge base—an invitation to learn together, to teach forward, and to build housing that reflects the best of what we know.

Because the truth is, none of us have it all figured out. But if we stay curious, stay generous, and stay in conversation, we might just get somewhere better.

Appendix

Future-ready building delivery checklist

This checklist identifies the critical tasks that must be executed by one or more members of the project team (architect, owner, builder, commissioning agent(s) and consultants). Careful coordination of the tasks among these key players is needed to ensure comprehensive project delivery. Complete guides to professional practice and competencies are available from other organizations. This checklist is not an exhaustive guide to all aspects of practice.

Pre-design

- ☐ Assemble integrated design team and appoint commissioning agent(s)
- ☐ Develop Basis of Design (BOD) and Owner's Project Requirements (OPR)
- ☐ Identify performance targets from applicable codes + standards
- ☐ Select MURB typology conducive to the zoning envelope
- ☐ Establish performance targets that anticipate future energy efficiency and emissions requirements, choose energy sources
- ☐ Identify number of suites, types and sizes, and building amenities, including parking
- ☐ Apply yardstick costing and notional scheduling to selected MURB typology
- ☐ Develop project pro forma based on preliminary design concept

Schematic design

- ☐ Conduct integrated design iterations to establish the following:
  - Building orientation and form factor
  - Structural system and materials
  - Facade and interior finishes
  - Window-to-wall ratio (WWR)
  - Overall effective R-value of building envelope
  - Heating, cooling and mechanical ventilation strategies
  - Mechanical, electrical and plumbing (MEP) + lighting
  - Landscaping and stormwater management
  - Prepare outline specifications for schematic design
- ☐ Confirm embodied carbon and energy performance targets
- ☐ Check costs and review project schedule
- ☐ Update project pro forma

Design development

- ☐ Refine passive measures and identify candidate building envelope systems
- ☐ Develop fully operational building energy model with active systems
- ☐ Incorporate measures to minimize peak energy demands
- ☐ Provide active cooling systems but also design passive measures to manage overheating for thermal resilience
- ☐ Design metering systems for adequate measurement and performance verification
- ☐ Reflect performance targets, tactics, and strategies in draft specifications
- ☐ Commissioning agent(s) to engage design document reviews, identify functional test sets, start operating and maintenance (O&M) manual, and finalize commissioning plan
- ☐ Review costs and schedule

Construction documents (drawings and specs)

- ☐ Focus on building envelope details and specifications—define basis of equivalence for substitutions
- ☐ Delineate which trade is responsible for integrating building envelope transitions (e.g., roof to wall)
- ☐ Commissioning agent to review air barriers and heating, cooling and mechanical ventilation systems
- ☐ Detailed LCA and energy modelling to confirm compliance with performance targets
- ☐ Ensure metering for thermal energy (heating and cooling), electricity, and water is included
- ☐ Indicate contractor obligations for accommodating quality assurance inspections and airtightness testing
- ☐ Keep it clean and simple

Bidding, construction, and commissioning

- ☐ Document Basis of Design (BOD) and Owner's Project Requirements (OPR) for inclusion in bidding packages
- ☐ Conduct on-site orientation sessions to review critical details and standard of workmanship with trades before commencement of each stage of work
- ☐ Establish milestones for airtightness testing and functional test sets of MEP systems—ensure contractor understands commissioning requirements
- ☐ Carry out random third party quality assurance and inspections
- ☐ Continuously document work on site and update as-builts

Building operation (start up and handover)

- ☐ Review final construction for compliance and quality, including operational tests, thermographic and airtightness testing
- ☐ Finalize as-built drawings and energy model
- ☐ Ensure commissioning and testing is fully completed—confirm all controls, setpoints, airflow rates, metering
- ☐ Handover operating and maintenance manual and ensure the building operator is properly trained and qualified
- ☐ Check and ensure that sensor and meter data are being properly recorded in the building management system (BMS) for long term performance assessment

Post-occupancy (operation and maintenance)

- ☐ Carry out maintenance and periodic inspections as per operating and maintenance manual
- ☐ After the first year of occupation conduct a post-occupancy evaluation with inhabitants; address issues and concerns
- ☐ Ensure the metering system is operating correctly and is regularly validated against utility meters.
- ☐ Track key performance metrics (energy and water consumption at minimum)
- ☐ Dedicate an annual budget for monitoring energy and water use, tuning controls and calibrating sensors
- ☐ Report and share energy and water consumption data

Applying this guide in professional practice: IDP

Designing for the future demands a shift from conventional practice to an integrated design process—balancing cost, performance, and long-term resilience. Minimum code compliance is no longer enough, as building standards continue to lag in climate action, sustainability, and durability.

The integrated design process is widely acknowledged as a practical means of designing buildings that are both economical and socially and environmentally responsible. By aligning performance objectives from the outset, this approach creates housing that is efficient, durable, and future-ready.

Earlier design input results in better, most cost-effective outcomes

The Integrated Design Process (IDP) is not a novel invention by architects. The aerospace, automotive, and electronics industries adopted this approach to design more than half a century ago. It is recognized as a means of integrating all product requirements while being reliably and cost-effectively delivered.

Modern buildings no longer reflect well-defined archetypes and vernaculars that were straightforward to design with conventional design processes. The assembly line model of design—where successive disciplines bolt-on various systems, components, assemblies, and equipment without understanding their interaction—has proven to result in poorly performing buildings with high operating and maintenance costs.

Integrating the building-as-a-system at the early stages of design helps produce buildings with enhanced life cycle performance. By adopting IDP, critical aspects of future-ready MURB design can be incorporated at all project stages.

Building codes set absolute minimums—not standards

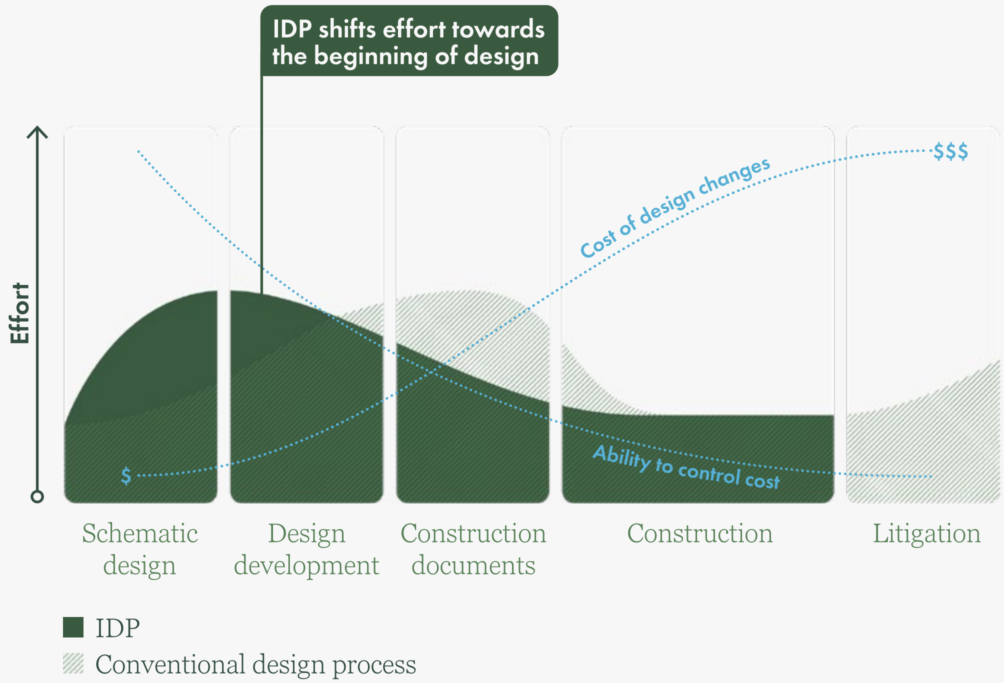
Building codes define the minimum legal requirements for construction, but they are not a measure of quality, efficiency, or resilience. They establish a baseline—one that ensures basic safety but often lags in critical areas like climate action, sustainability, and long-term durability. Designing to code alone is a missed opportunity to create buildings that are more efficient, adaptable, and cost-effective over time.

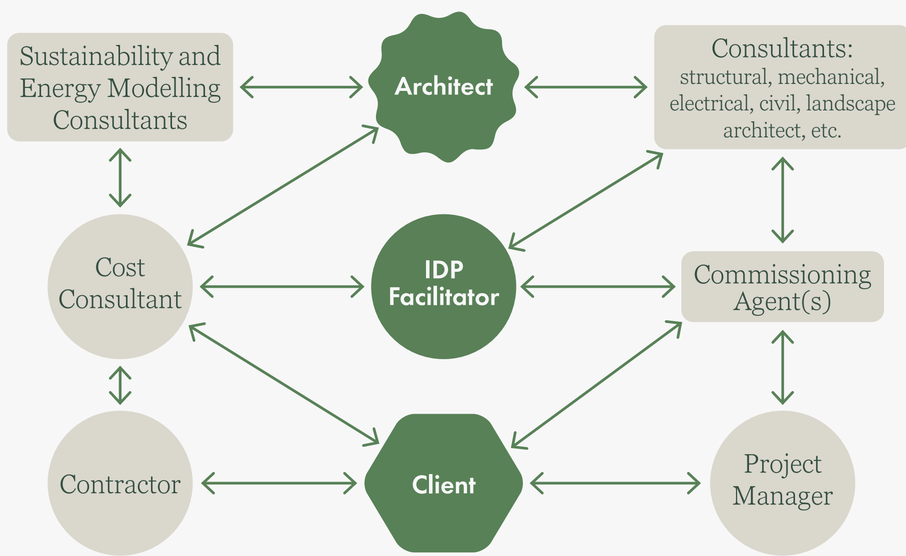
Codes will continue to evolve, but they often do so reactively, playing catch-up with new research, technologies, and environmental realities. Architects have a responsibility to design for the future—not just to the lowest acceptable standard. By going beyond code, we can create buildings that are more energy-efficient, resilient, and adaptable, ensuring lower life cycle costs and better long-term performance for owners and occupants alike.

But isn't code-minimum cheaper?

Meeting only the minimum code requirements often results in buildings with higher operational costs, lower resilience, and reduced occupant comfort. Poor energy performance leads to rising utility bills, outdated material standards increase maintenance needs, and insufficient durability shortens a building's lifespan.

In housing, this means greater exposure to extreme temperatures and compromised security—ultimately reducing affordability and livability.





The IDP advantage

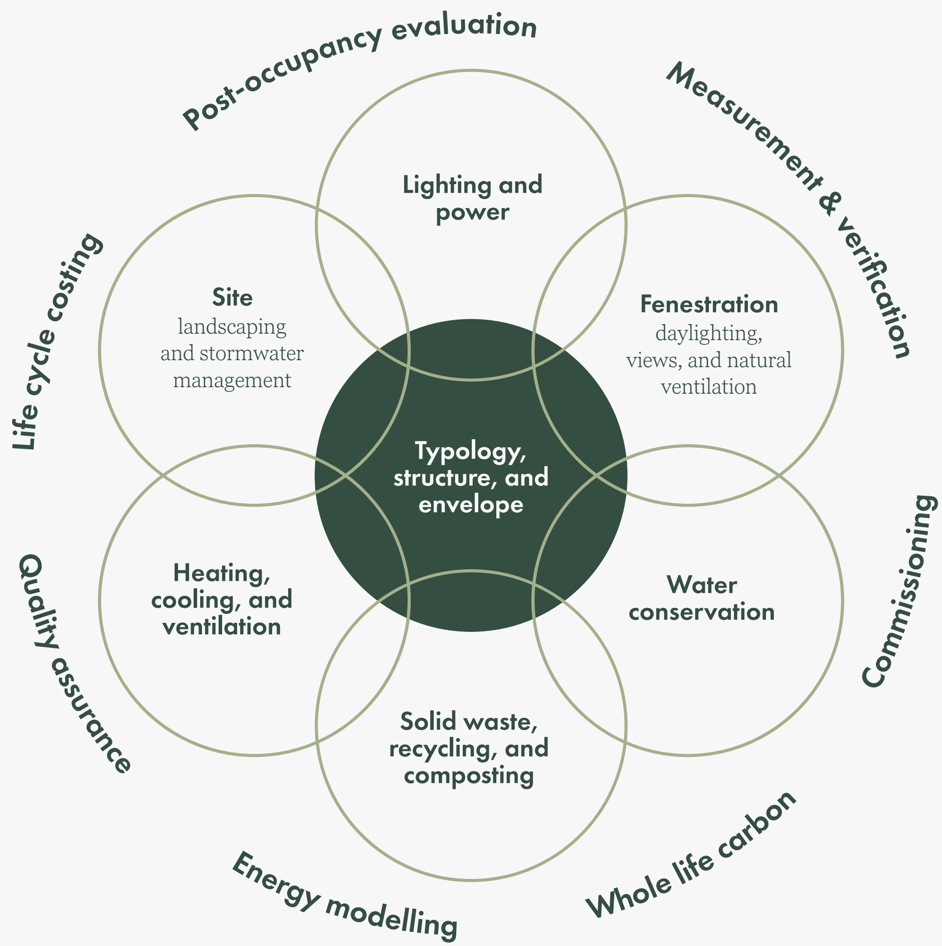
By reallocating resources to the early stages of a project, IDP is better able to control costs by minimizing later stage design changes, which is often the case with the conventional design process.

Focusing on key considerations for future-ready design allows the owner's project requirements and performance targets to run a lower risk of being value-engineered out during design development.

Players and process

Starting at the pre-design phase of a project, the key players involved in the design and delivery of the building are engaged in a collaborative process by a facilitator. The facilitator's role is to ensure key decisions and the critical aspects of the design are resolved before commencing schematic design. All players are also engaged throughout subsequent stages as required.

Click here to view resources for the Integrated Design Process.



Critical design aspects and activites

The design of all critical aspects of the building project entail activities by the various key players. These must all be integrated within the framework of the owner's project requirements.

Instead of executing the design stages like an assembly line, with each key player sequentially contributing to the design, IDP focuses on the holistic integration of the building-as-a-system.

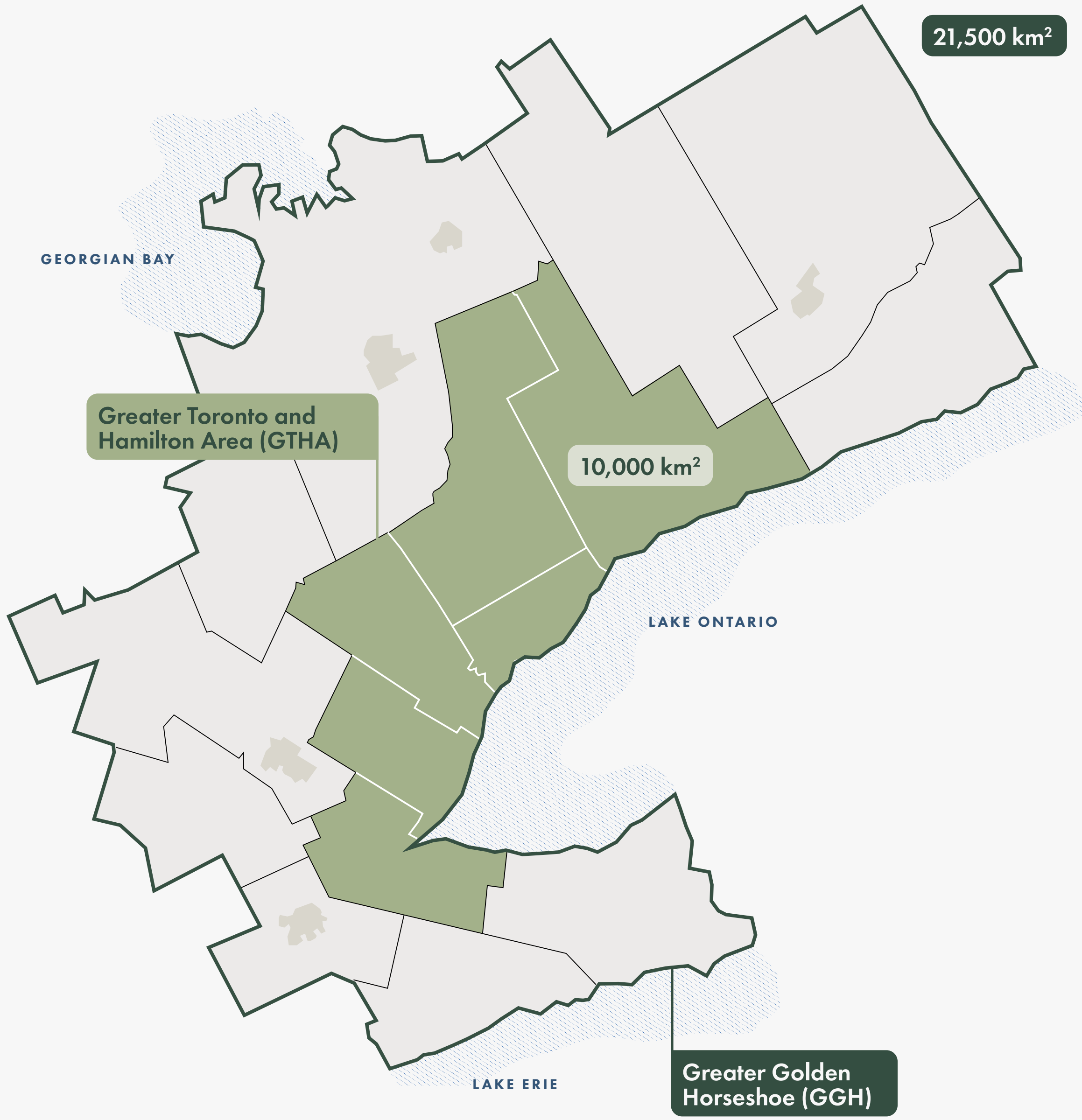
The Greater Golden Horsehoe in Detail

Context matters

Designing MURBs in the Greater Golden Horseshoe (GGH) region of Ontario demands at least a cursory understanding of the local context.

While many strategies may be applicable to similar North American climates, unique regional factors—such as proximity to the Great Lakes, a unique Ontario electrical supply, and rapid urbanization—necessitate tailored approaches.

This section outlines key considerations for practitioners working to address future ready multi-unit residential building design in Southern Ontario.



Population

43% of Canada's immigration lands in the GGH. Immigration is the most significant driver of population growth, and is highly subject to policy change.

Ontario's age profile is young. By 2036, the share of seniors aged 65+ will peak and then decline.

The Greater Golden Horseshoe (GGH)

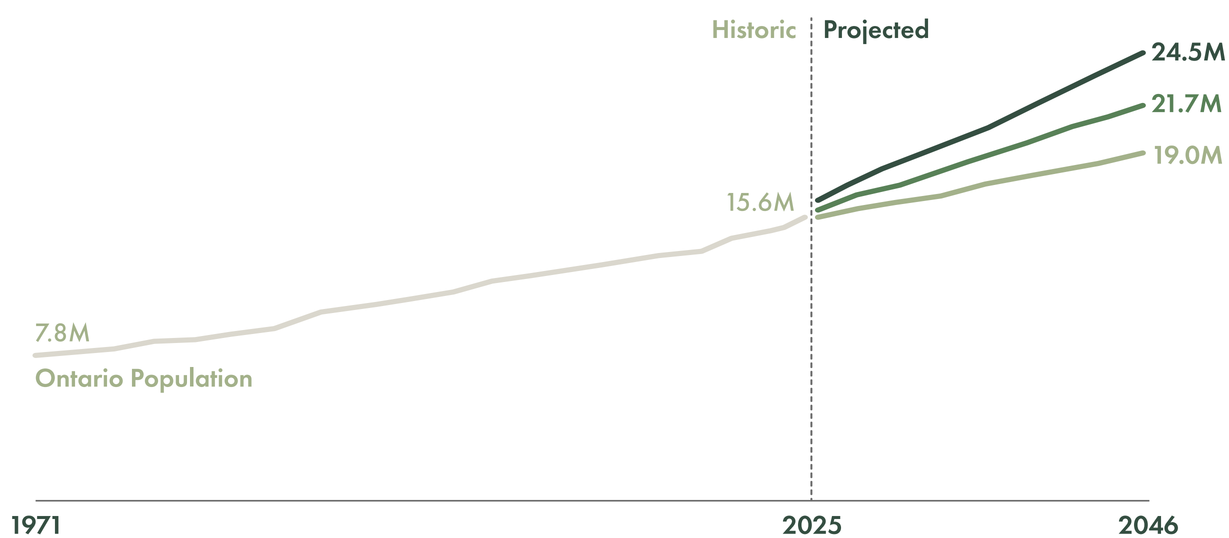
The GGH is Canada's most densely populated and industrialized area, housing over 9.7 million people—over 20% of Canada's population—and generating approximately half of Ontario's greenhouse gas emissions.

Rapid population growth, fueled by immigration and concentrated in metropolitan centres, underscores the need for sustainable housing solutions. With demand for MURBs set to rise, avoiding highly inefficient and costly urban sprawl while accommodating growth will be a central challenge for architects and planners.

Population growth is concentrated and high

Among the 15 most populous metropolitan areas in North America, the Toronto Census Metropolitan Area ranks second in population growth. In 2023, Ontario welcomed 43% of Canada's immigrants, driving much of the province's overall growth.

Notably, this growth is heavily concentrated in metropolitan areas, with Toronto experiencing the largest share.

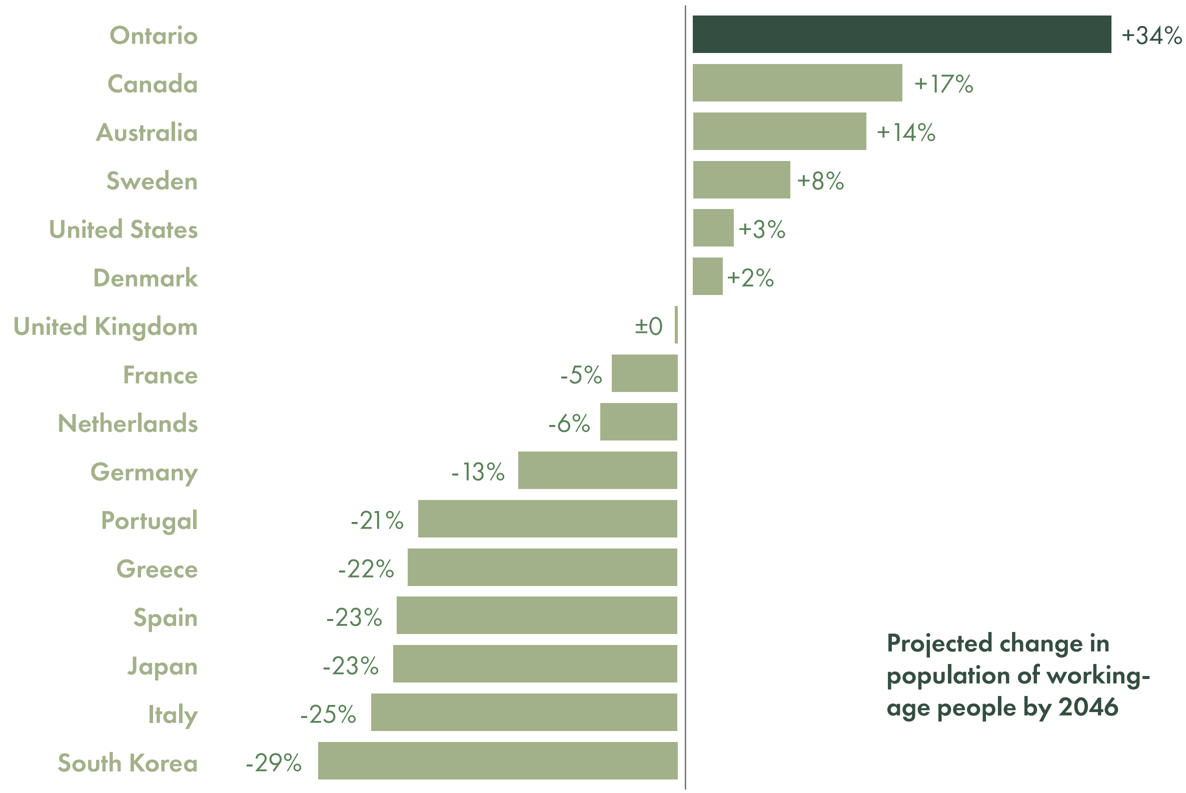


Ontario is remarkably young

Young international migrants fuel most of Ontario's growth, with 80% of immigrants under the age of 40. As a result, Ontario's age profile is younger than a vast majority of other developed economies.

This means that the share of seniors aged 65 and older—the "baby boomer" generation—is projected to reach its peak by 2036, followed by a significant decrease. Ontario's share of working-aged residents is growing at a tremendous rate—double that of Canada's national rate and much higher than other developed economies.

Natural increase, or population growth from births, is negative in most parts of the province except the GGH. Regardless, population growth continues to be positive across the board due to migration.



Projected change in population of working-age people by 2046

Economics

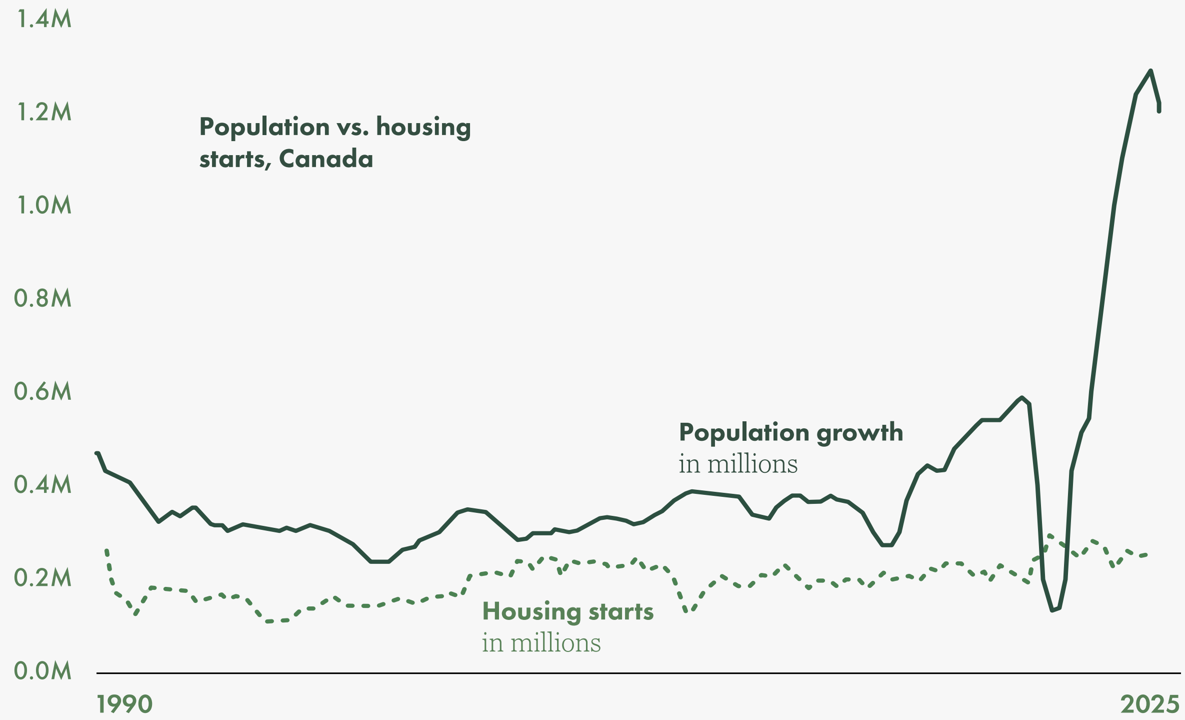
Income has not kept up with the cost of housing, and neither has supply

The cost of housing in this region has become severely decoupled from median income. Looking at metropolitan areas, Toronto is second only to Vancouver when it comes to the cost of housing relative to earnings, with both cities being far above the Canadian average.

Nationally, housing construction has lagged behind population growth, highlighting a clear need for more starts. However, addressing the housing crisis also requires tackling the commodification of housing, which has priced out individual buyers in favour of speculators and multi-property owners.

Don't compromise passive measures, durability, or resilience when looking for savings—focus on cutting items that can be easily upgraded in the future.

Since 1990, median income has decreased by 3% while home prices have increased by 409%



Lack of supply is not the only factor contributing to the housing crisis. Stagnant incomes and speculation have also fueled unaffordability in the region.

Construction costs have doubled

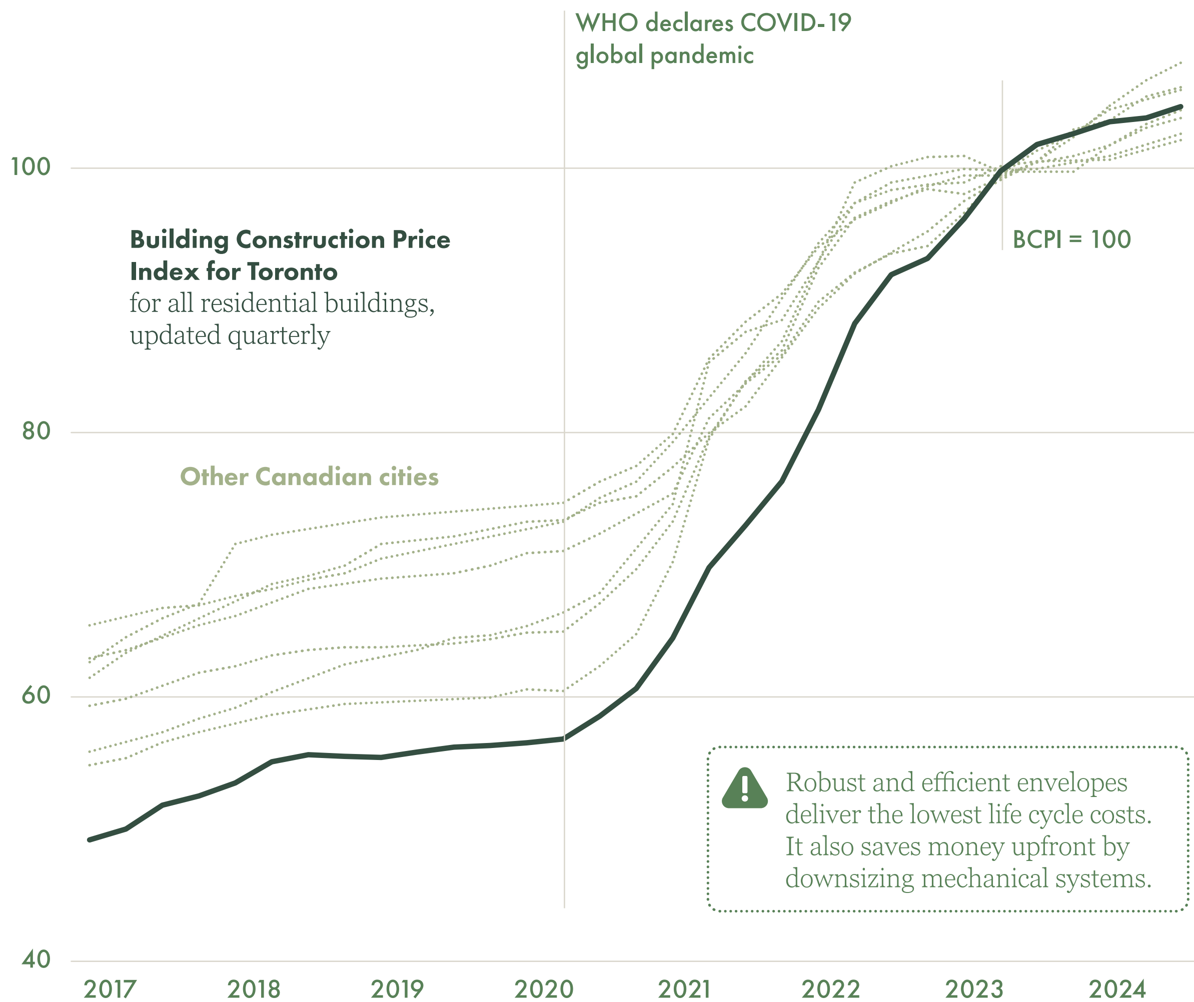
The cost of building in Toronto have more than doubled since 2017—the start of record keeping for the current Building Construction Price Index (BCPI). The data tracks the change in construction cost for all residential building types from a contractor's point of view, accounting for materials, labour, equipment, overhead and profit.

In 2017, Toronto's BCPI was the lowest amongst major Canadian cities. By Q3 2024, Toronto was in the middle of the pack. Steep upward changes in BCPI coincide with the global COVID-19 pandemic and supply chain disruptions; however, in the aftermath of these events, BCPI has not seen a significant correction, continuing to increase with a narrower spread amongst major cities.

Consider life cycle costs

Building more housing should not come at the expense of lowering standards. While lower initial construction costs may reduce upfront expenditure, they almost always lead to increased operating and maintenance expenses. High energy bills and upkeep costs burden residents and communities with unaffordable expenses over time.

The cost premium of high performance construction may also be overblown: the median construction cost increase for building MURBs to Passive House standards was 4% in 2021.



Robust and efficient envelopes deliver the lowest life cycle costs. It also saves money upfront by downsizing mechanical systems.

Energy and infrastructure

Ontario's electricity is amongst the greenest, but we still rely on fossil fuels

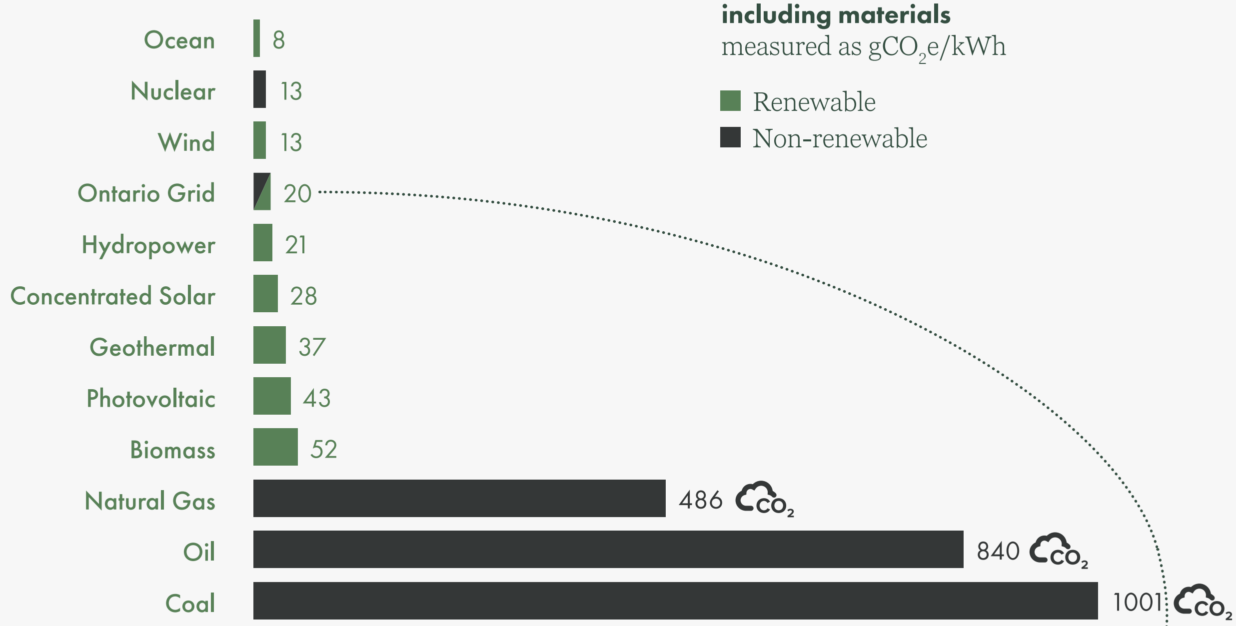
Ontario produces 91% of its electricity from non-emitting sources, including nuclear, hydro, wind, and solar. Nuclear power provides a majority of Ontario's electricity, and recent commitments to nuclear reactor refurbishments and new, Small Modular Reactors (SMRs) will likely see this trend continue.

Ontario's grid intensity, gCO_2e/kWh—or about the amount of CO_2 emitted to run a microwave for one hour—is amongst the lowest in Canada at 20 gCO_2e/kWh.

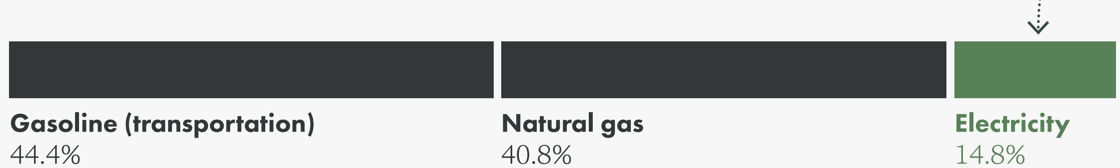
However, household demand tells a different story. While our electrical grid is green, many households still rely largely on gasoline and natural gas for transportation and heating, respectively.

> Affordable housing and energy poverty often overlap, where residents cannot afford high energy bills. Designing efficient, durable buildings has an outsized impact on total affordability.

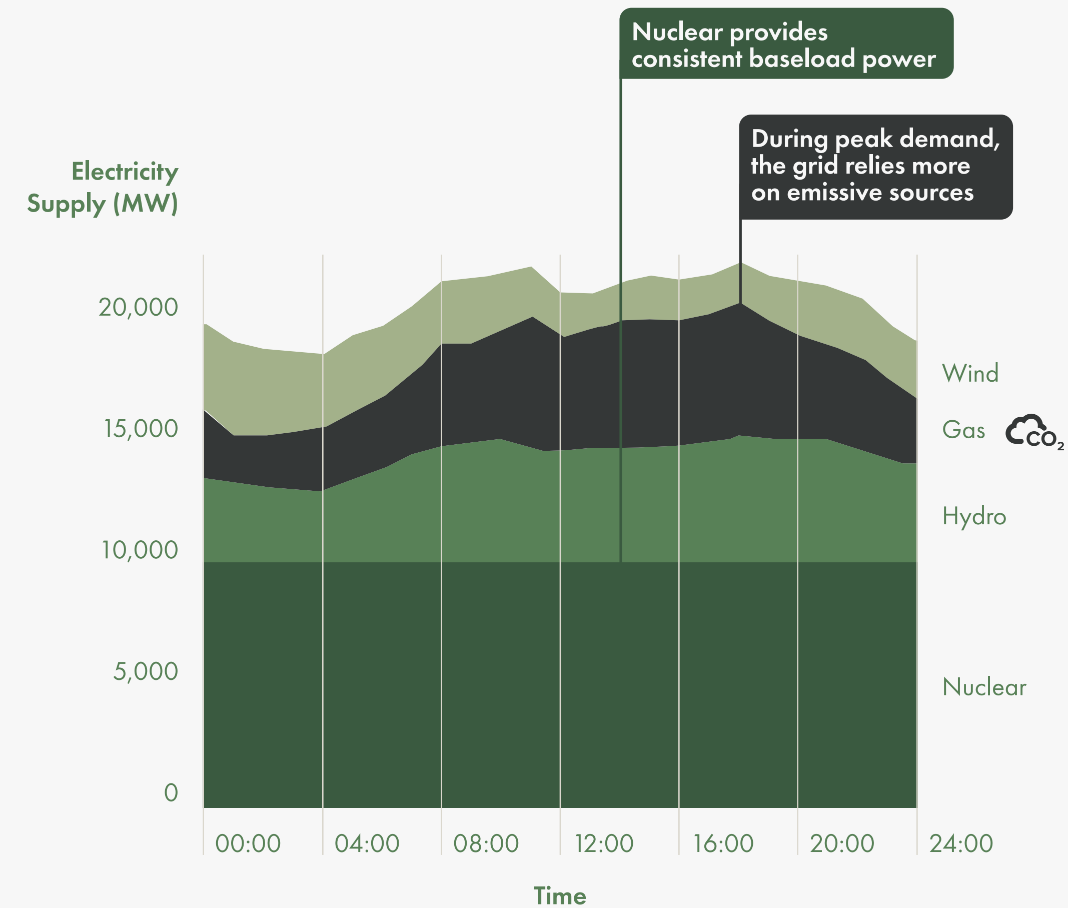
Greenhouse gas emissions from electricity generation, including materials
measured as gCO_2e/kWh



Household energy consumption in Ontario



Intensification of urban development and the design of complete communities can reduce the consumption of gasoline for commuting and encourage public transportation



Efficient design and energy storage can reduce reliance on peak electricity—when electricity is most emissive and expensive.

The future is largely business as usual

In a short span of time, from 2005 to 2022, Ontario reduced its grid intensity by 84%. Looking towards the future, equally large changes in either direction are possible.

While the province has committed to increasing its hydro and nuclear power capacity, including building energy storage capacity for renewables, the province has also expanded natural gas programs for rural and new communities. This means that practitioners must consider the diverse energy mix of Ontario in their designs when thinking about sustainability and operational affordability.

Peak demand influences cost, resilience, and carbon footprint

Peak electricity demand is an important consideration for energy grids worldwide. In Ontario, energy use in the evening can be double the use in the morning. During peak periods, carbon emissions in the grid are at their highest as non-baseload power plants—such as GHG-emitting natural gas plants—kick in.

Due to air conditioning, Ontario has its highest demand for electricity in the summer; however, with the electrification of heating and transportation, the province is expected to *dual peak* in both the winter and summer by 2030.

Climate change

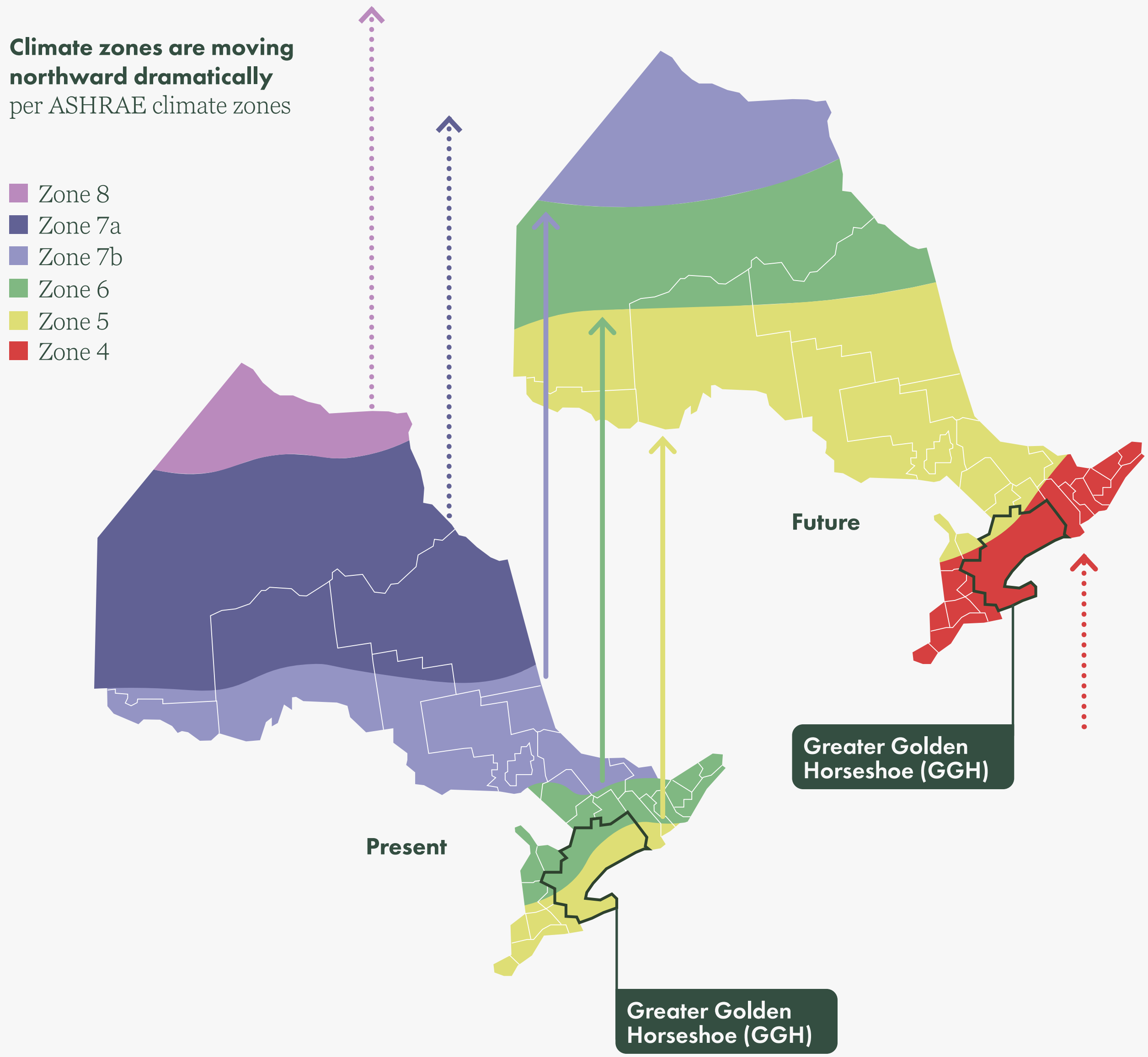
Within our lifetimes, climate change will challenge the livability of our buildings

Building codes and other regulations are poorly equipped to anticipate future climate conditions. Future-ready MURBs must look ahead, beyond minimum requirements, since these consequences are in the near-future.

Expect more frequent and extreme flooding and sewer backups. More precipitation means wetter buildings that stay wet for longer. Solar heat gains—today a tool for reducing heating demand—will become problematic for future overheating. Highly efficient ERVs will conserve energy, reduce peak demand, and improve indoor air quality.

Designing for climate change is manageable if the changes are anticipated and properly accommodated early-on in the design process.

> Flooding, wetting, heat, and cold present challenges in the near-future. Consider these challenges pragmatically early-on in schematic design.



The cost of business as usual

Since the 1970s, the cost of extreme weather events has gone up 12-fold to an average of $112M per event. These costs have direct implications on the affordability and availability of housing, as extreme weather threatens to displace residents from flooded, frozen, or burnt-out homes. Higher claims and higher premiums may make some Canadian regions uninsurable.

The housing crisis demands new housing stock that remains in supply long-term; extreme weather puts this at risk. Extreme heat events, flooding, and poor air quality will put stress on buildings, landscapes, and infrastructure. Underinvestment in public works means reliability of infrastructure may be compromised.

According to the Insurance Bureau of Canada, flooding comprises the highest risk to the Canadian built environment; buildings are identified as needing the most investment.

> Our region is not adapted to nights over 20 °C. People, spaces, and ecosystems will struggle to recover from hot daytime temperatures when the night is also warm.

What does climate change mean for our region?

Global GHG emissions continue to grow to record-breaking levels, most recently exacerbated by wildfires. Consequently, evidence shows trends moving towards high-change scenarios.

Climate scientists have indicated that some of the most significant shifts in climate and extreme weather events are occurring in Canada, including the GGH. Warmer, wetter winters and hotter, wetter summers are forecast just several decades into the future, accompanied by more frequent and severe extreme weather events, even in the most conservative projections.

These trends mean the GGH can expect to see increased flooding, new pests and diseases, loss of native species, declining ecosystems, and other impacts on human health.

	Historic	Projected		
	1976-2005	2051-2080		
	Mean	Low	Mean	High
Days over 30 °C per year	12	31	55	80
Nights over 20 °C per year	8	28	47	69
Annual precipitation	793 mm	699 mm	870 mm	1058 mm

Urban heat islands—something practitioners can easily control—amplify the consequences of hot weather

Vegetation cools the air by absorbing sunlight and dispersing heat through evaporation. In contrast, hard surfaces in cities trap heat, raising daytime temperatures by up to 3 °C and nighttime temperatures by up to 12 °C. This build up of heat has deadly consequences, particularly in buildings without air conditioning. When mapped, these swaths of hot areas are called Urban Heat Islands (UHIs).

Architects and designers can help curb UHIs by specifying reflective, low albedo roof coverings, planting green roofs, and providing landscapes. Mitigating these effects benefits both the building and the community around it.

Urban heat islands have fatal consequences for people without access to cool spaces. Passive strategies to reduce or reverse this phenomenon provide community-wide benefits.

Ground surface temperatures in the GTA on a summer day in 2020; the impact of built-up urban areas on temperature are visible - *Contains information made available under the Toronto and Region Conservation Authority (TRCA)'s Open Data Licence v 1.0*

What does climate change mean for heating and cooling?

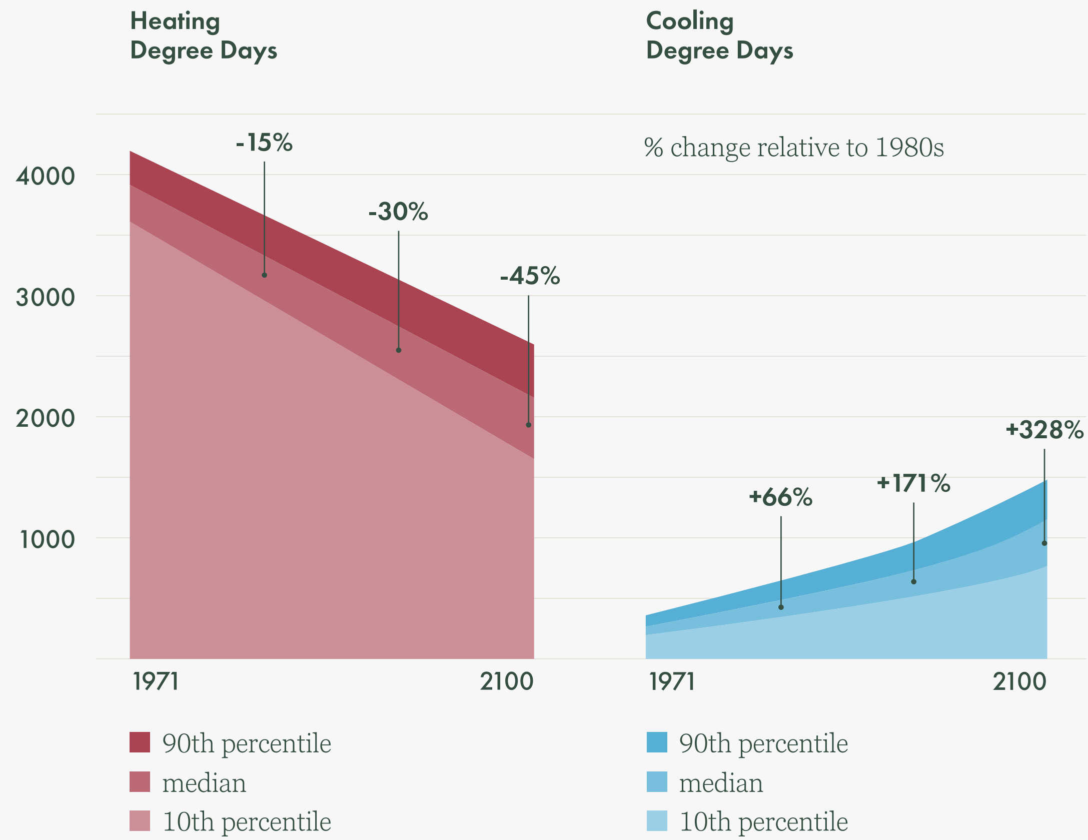
For housing built today, a majority of its useful service life will experience a changing climate. Buildings will need as much cooling as heating, and heat waves will become more extended and more common. Hot weather resilience will take priority over cold weather resilience. On-site emergency power generation might be required for essential functions, including cooling.

Heating Degree Days (HDD) are expected to continue to decline, while Cooling Degree Days (CDD) may triple or quadruple by 2080, with over 100 days per year above 30 °C. A new, mixed-climate is likely in our future, subverting the heating-dominated climate we are accustomed to.

What does this mean for housing?

Housing is our first line of shelter. When extreme weather events cause extended power outages, buildings must be able to provide habitable shelter under both cold and hot conditions for as long as possible—at least until power can be restored. Buildings that depend on active systems to maintain climate will fail sooner than buildings designed with passive strategies.

Current codes and standards do not capture climate resiliency. It is up to practitioners to go beyond minimum requirements to design durable, resilient, and safe buildings that account for our changing climate.



Expect much more demand for air conditioning and less demand for heating in the future.

Heating and Cooling Degree Days (HDD/CDD) are the number of degrees above or below 18 °C multiplied by the number of days the temperature isn't 18 °C. It is a useful measure of how much cooling or heating is required.

≠18 °C x number of days

Hydrology and water infrastructure

On-site stormwater management is necessary to reduce burden on overstretched sewage infrastructure, which protects our fresh water supply.

The Great Lakes Basin—a globally significant supply of fresh water

The GGH is part of the Great Lakes basin, a vast resource containing one fifth of the world's fresh surface water. The basin receives runoff from numerous streams and rivers that naturally drain into it.

Stormwater from urban areas is also conveyed to these water bodies. Extreme rainfall and snowmelt events, which are increasingly common, force untreated sewage and vast quantities of storm sewer outfall into the Great Lakes Basin. These flows carry road salt and other pollutants from streets and buildings into the basin, adversely affecting ecosystems and drinking water.

Why manage stormwater on-site?

Much of our urban sewage and stormwater infrastructure did not anticipate today's levels of urbanization. These systems are simply over stretched and over capacity, and it may not always be feasible to upgrade them.

Climate change has led to more frequent and intense rainstorms, resulting in severe flooding of streets and buildings across the GGH. As urbanization accelerates, on-site water management regulations have become increasingly critical for new developments. Effective stormwater management begins at the source, with strategies like infiltration and absorption to retain rainwater on-site. From there, runoff can be directed to bio-swales and retention basins, ensuring outflows match pre-development levels.

Rainwater harvesting is another key tool, allowing rainfall to be captured and reused for irrigation and toilet flushing. Additionally, regional conservation authorities play an active role in regulating stormwater measures and enforcing requirements for water quality and erosion control. Architects and designers must navigate these regulations to ensure MURB developments are resilient and aligned with best practices for sustainable water management.

Building in our ravines (or the lack thereof)

Conservation authorities across the GGH have restrictions around building near ravines or other portions of land adjacent to rivers and creeks.

In 1954, the overflowing rivers of Hurricane Hazel swept entire houses off their foundations, eroded shorelines, and destroyed dozens of bridges and roads, leaving 81 dead and nearly 1900 families homeless. It is in the aftermath of this disaster that a concerted effort was made by local conservation authorities to restrict development in flood plains and sensitive areas, reducing risk to the public.

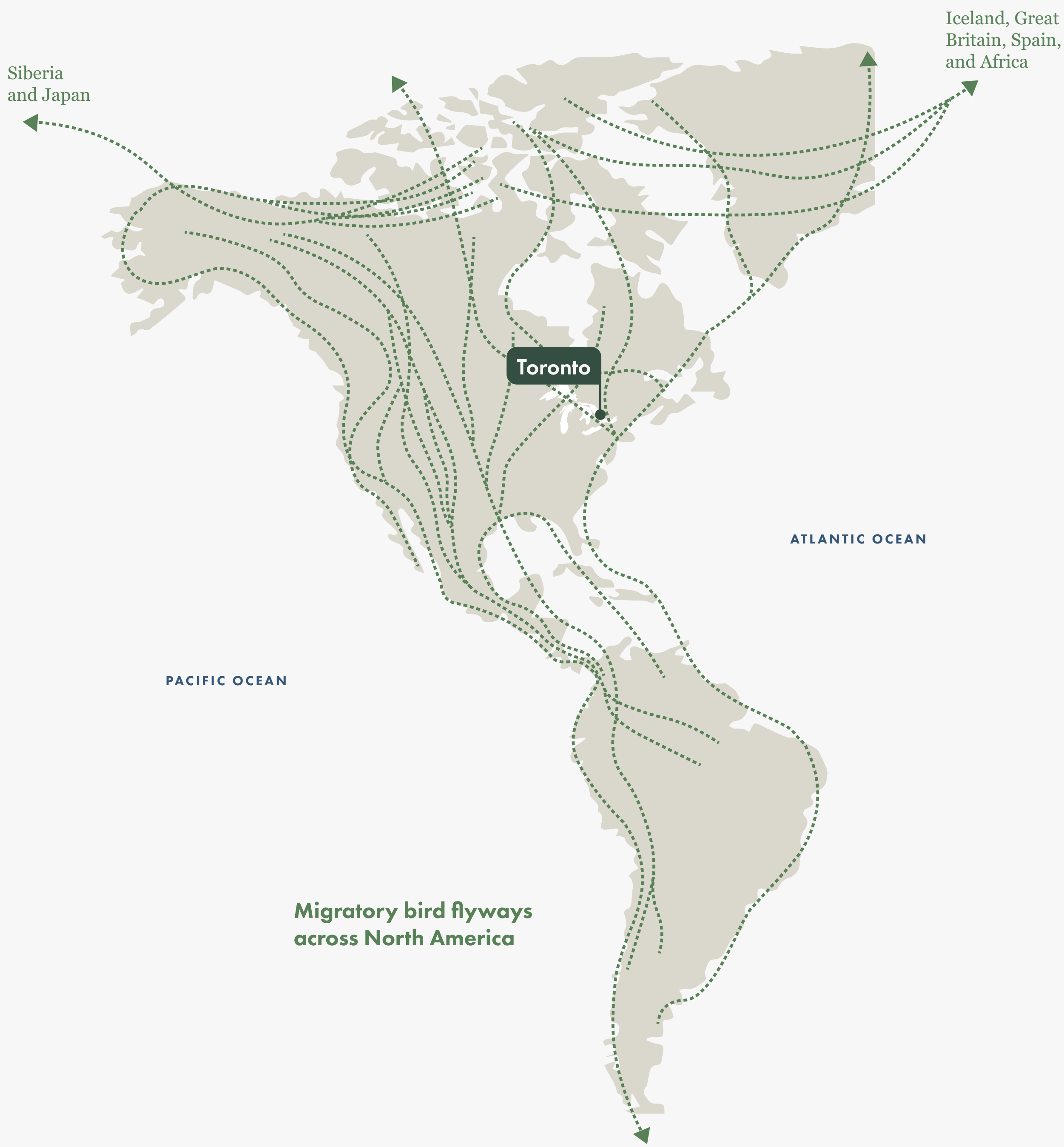
Ecology and biodiversity

A crisis for migratory birds

In Canada, an estimated 25 million birds die annually from window collisions, with Toronto seeing a disproportionately high number of these fatalities. As both the confluence of the Atlantic and Mississippi Flyways and home to one-third of Canada's tall buildings, Toronto poses a significant hazard for migratory birds.

Bird-friendly glazing and dark-sky compliant lighting, now required in many GGH jurisdictions, are essential measures to address this ongoing crisis.

Many migratory birds fly at altitudes similar to the extent of MURBs between 4-18 storeys. Integrate bird-friendly glazing and other strategies to minimize wildlife collisions.



Using natural systems—such as trees, green roofs, and wetlands—to address infrastructure needs is more economical and resilient than engineered systems.

Biodiversity has tangible benefits for ecosystems and human communities

Urban development across the GGH is putting immense pressure on the region's natural ecosystems. Prime agricultural lands and habitats that support biodiversity are being lost, threatening flora, fauna, and ecological health. Protecting ravines and natural features while promoting native species is critical to maintaining climate-positive landscapes. Green roofs, native trees, and cool paving work together to reduce the urban heat island effect, manage stormwater, and create healthy environments for small mammals, birds, and insects.

Ecological services cost less than engineered infrastructure

The design of MURBs can enhance ecosystems while offering cost-effective solutions to community challenges. Green infrastructure, such as bio-swales, rain gardens, and vegetative roofs, manages stormwater on-site by mimicking natural processes. These features reduce reliance on costly, high-maintenance engineered systems and adapt more effectively to climate extremes and long-term environmental changes.

Restoring natural elements like wetlands, tree canopies, and permeable landscapes not only improves stormwater management but also enhances biodiversity, mitigates urban heat islands, and improves air quality. Unlike traditional infrastructure, which often requires expensive repairs and upgrades, green infrastructure provides resilience and long-term value. By integrating these solutions, MURBs can create healthier, more sustainable communities while reducing costs and improving environmental performance.

What does the Greenbelt have to do with housing and development?

The GGH is home to the world's largest Greenbelt—an 800,000-hectare (2 million-acre) region of protected farmland, forests, wetlands, rivers, and lakes.

The Greenbelt safeguards watersheds that provide clean drinking water, mitigates flooding by absorbing excess stormwater, and helps regulate local temperatures by reducing the urban heat island effect. It also protects some of Canada's most fertile farmland, ensuring long-term food security for the region.

The shape of the Greenbelt intensifies urban development by restricting the horizontal spread of cities, curbing unchecked urban sprawl. Sprawl stretches infrastructure and mobility inefficiently, increasing costs for roads, utilities, and services, while simultaneously removing farmland and natural features—compounding environmental and economic impacts.

Building regulations and performance standards

Building codes and standards are usually revised every 5 years, but housing must endure for generations. Designing to minimum standards is not future-ready and impairs durability, resilience, and sustainability. Design buildings to have value, dignity, and livability in their old age.

The Ontario Building Code and beyond

New developments in the GGH must comply with the Ontario Building Code, now harmonized with the National Building Code of Canada (NBC). Architects also face additional layers of regulation from conservation authorities, municipal green standards, and by-laws addressing sustainability measures like green roofs and bird-friendly glazing. Together, these rules aim to ensure that buildings are both environmentally responsible and community-oriented.

The 2024 Provincial Planning Statement (PPS)

In October 2024, Ontario introduced the Provincial Planning Statement (PPS), replacing the 2020 Provincial Policy Statement and the 2019 Growth Plan for the GGH. This new framework reshapes how municipalities manage land use planning and development, limiting local control while standardizing growth policies across the province.

Municipalities that previously implemented progressive green standards or enhanced stormwater management policies might now face constraints in advancing localized climate-focused initiatives, putting more responsibility in the hands of practitioners and developers.

Municipal green standards

As of 2024, nearly 30 Ontario municipalities have implemented building sustainability standards that go above and beyond Ontario's building code. Toronto, and the nearby municipalities of Halton Hills, Whitby, Ajax, Brampton, Markham, and Vaughan all have green standards.

Exemplary green standards include predictable pathways for industry to achieve net-zero emissions by 2050. These pathways provide incremental steps towards net-zero emissions.

Municipal bylaws can regulate minimum and maximum temperatures

Most municipalities in the GGH mandate a minimum interior temperature of around 20 °C—or 21 °C in the case of Toronto—for rented apartments and suites. Landlords are required to provide adequate heating during cold weather to meet these minimum temperatures.

In the city of Toronto, a maximum temperature of 26 °C must be maintained in summer months for buildings with air conditioning. Toronto is the first GGH municipality to introduce a maximum temperature bylaw; other municipalities, such as Hamilton, are expected to follow suit.

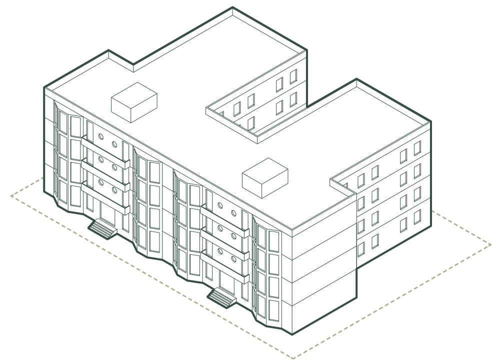
PIMBY

(Precedents In My Backyard)

When it comes to designing purpose-built MURBs, we don't have to look far to find great examples. Toronto has been building MURBs for over a century (despite a somewhat rocky relationship, including a ban on apartments in 1912).

Studying local precedents, right here in our own backyard, provides context-specific teachings on how MURBs can best respond to Toronto's unique fabric and cultural context. Older precedents have much to teach us about passive systems and fitting into Toronto's long and narrow lots, while the 60s boom has valuable learning opportunities about affordability and efficiency.

So here are some Precedents In My Backyard—or PIMBYs.

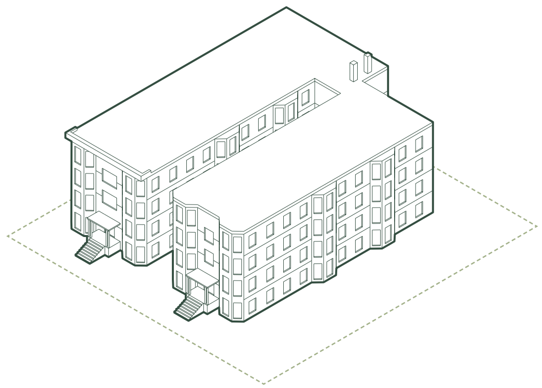


Spadina Gardens

Arthur R. Denison (1905)

No. of units	24
Height	4 storeys
Lot area	1700 m^2
Density (units per hectare)	141

Spadina Gardens is amongst the city's earliest apartment buildings, and the oldest to still be used as a residential building. Like other early examples, its design targeted the city's more affluent citizens with unit layouts that included familiar features of large houses of the period. Its corner lot location and courtyard maximized access to light and fresh air.

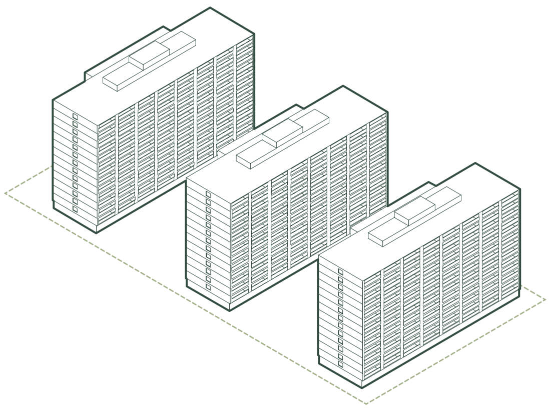


The Maitlands

Robert Henry Bullen (1910-1912)

No. of units	55
Height	4 storeys
Lot area	2440 m^2
Density (units per hectare)	225

Part of Toronto's first apartment building boom, The Maitlands are typical of their era. To maximize unit count and size, the building covers most of the lot and features a first floor raised half a storey above grade to provide light to basement suites. Only the street-facing façade is ornate, recognizing other buildings would likely emerge on either side.

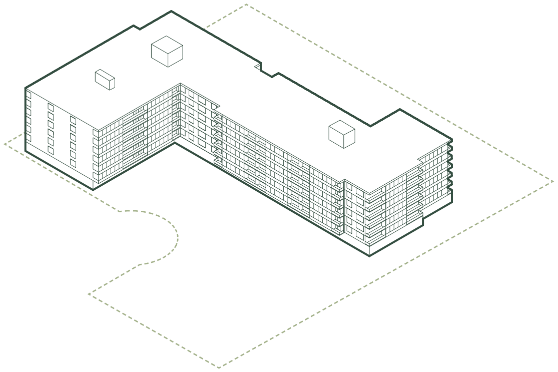


City Park

Peter Caspari (1956)

No. of units	774
Height	14 storeys (x3)
Lot area	16,557 m²
Density (units per hectare)	466

Considered the first modern apartment complex in the city, City Park is representative of the “tower in the park” model. Slab towers offer shallow and efficient layouts, prioritizing light and air while being affordable to build. Between 1952 and 1972, Toronto would build 500,000 rental apartments with nearly the same floor plan and construction system.

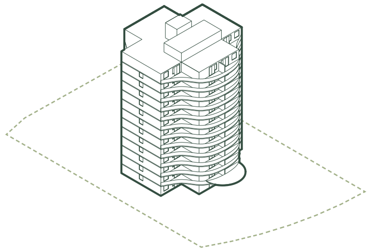


Benvenuto Place

Page and Steele (1955)

No. of units	119
Height	7 storeys
Lot area	11,260 m²
Density (units per hectare)	105

An exceptional example of Modernist residential design led by Peter Dickinson, Benvenuto Place takes advantage of surrounding natural features (in this case a steep escarpment) to create units with a deep connection to place. The modernist building originally combined a mix of residential and hotel units, as well as a restaurant.

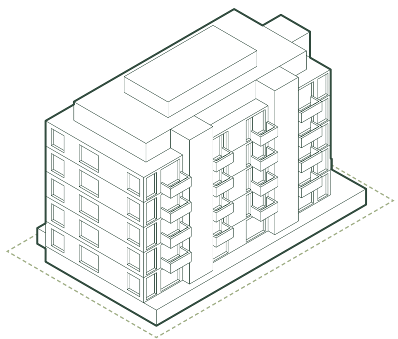


44 Walmer

Uno Prii (1965)

No. of units	85
Height	13 storeys
Lot area	3100 m²
Density (units per hectare)	274

Uno Prii’s apartments are amongst the most distinctive in the city. Prii was concerned that repetitive, unadorned modernist apartments lacked identity, so he wrapped efficient building forms with sweeping curves, ornate balconies, and sculptural entrance canopies to provide identity without sacrificing functionality.

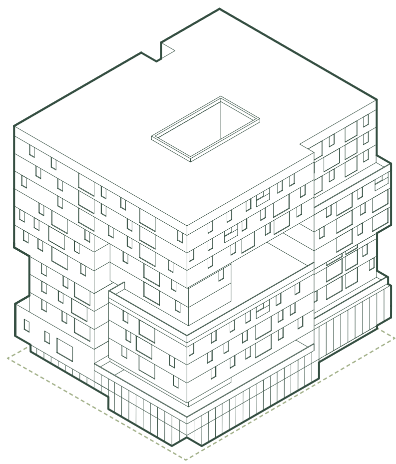


20 Niagara

Wallman Clewes Bergman (1997)

No. of units	22
Height	6 storeys
Lot area	840 m^2
Density (units per hectare)	262

Occupying the full depth of the floorplate, the apartments at 20 Niagara are rare Toronto examples of through-units—with access to air and light on both sides. This compact building has been designed without public corridors, with access to units done through two small elevator cores and using a shared balcony as access routes to the required exit stairs.

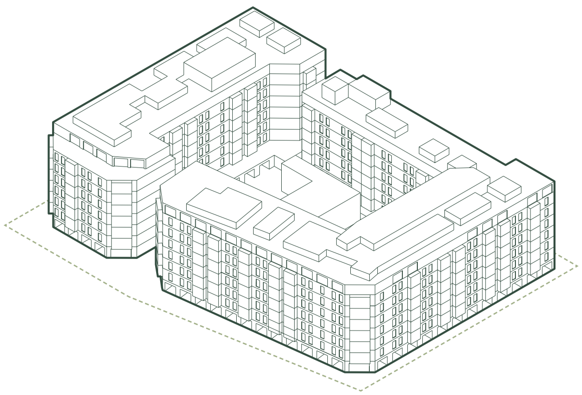


60 Richmond

Teeple Architects (2010)

No. of units	85
Height	11 storeys
Lot area	987 m^2
Density (units per hectare)	861

Somewhere between a tower and courtyard building, this Toronto Community Housing project manages to be sculptural while also integrating a 40% WWR, rainwater harvesting for irrigation, and an insulated cladding system without thermal bridging. Its location on a corner lot with a laneway allows it to maximize units and access to windows.



Market Square

Jerome Markson (1983)

No. of units	119
Height	8 storeys
Lot area	10,700 m^2
Density (units per hectare)	111

A counter to tall towers, Market Square achieves density through a perimeter block design reminiscent of cities like Paris and Barcelona. The ground floor is reserved for commercial use, while a resident greenspace is located on a second-floor courtyard. The availability of large brownfield sites enabled this form, which requires large tracts of land.

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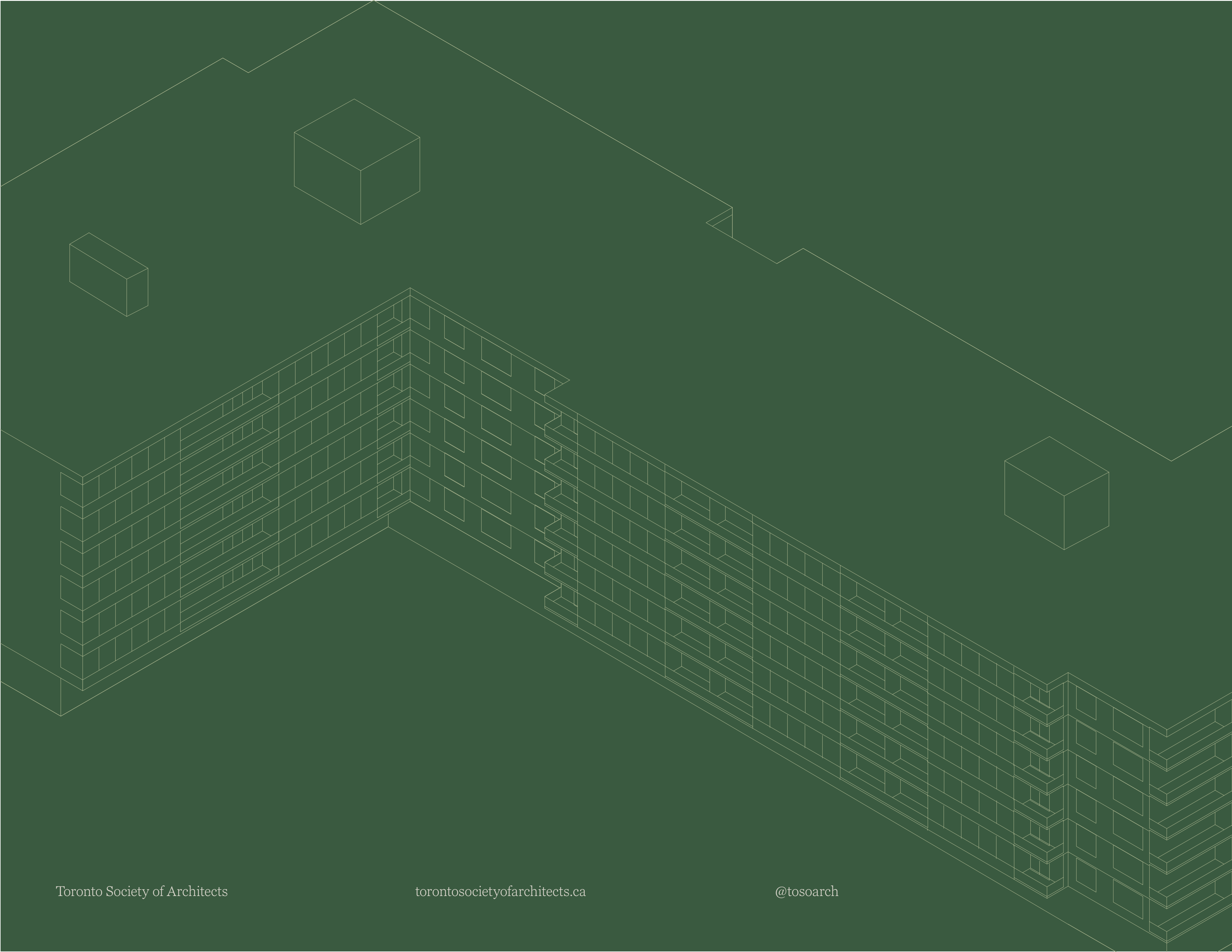

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