

Designing for a Low-Carbon Future

Why Carbon-Conscious Design Matters Now: Climate Change, Passive House, Net-Zero & Low-Carbon Design

Presented by
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Welcome

I work across architectural and interior design, project planning, and material-focused environments — with a growing focus on how the built world shapes our climate future.

This presentation started with a simple question: How can we make sustainable design easier to understand — and easier to apply in real projects?

My goal is to connect the dots between climate change, Passive House, Net Zero design, bio-based materials, and carbon-conscious decision-making — in language that's clear, practical, and built for real use.

This presentation is an invitation to think differently about the responsibility and opportunity we have as designers, builders, students, and decision-makers.

Z. Nevbahar Bilgeman

Architectural Designer | PMP | Founder, Novus Project Studio



Presentation Overview

1.Climate Change
Where we are and what is ahead

2.Key Terminology
Building a shared language

3.Passive House
Designing for efficiency first

4.Net-Zero Housing
Balancing energy use and production

5.Low Carbon Design
Designing with bio-based materials and engineered low-carbon materials

6.Carbon-Conscious Decision-Making
From awareness to action: a practical strategy





Let’s Talk About Facts

1. The buildings and construction sector accounts for about **34% of global energy demand** and **34% of global CO_2 emissions.**

2. By 2050, nearly **68% of the world’s population** is projected to **live in urban areas** – adding around 2.5 billion more people to cities.(13,213 urban buildings per day)

1.Source: GlobalABC / UNEP, Global Status Report for Buildings and Construction 2024/25

2.Source: United Nations DESA, World Urbanization Prospects





3. Climate change and land-use change are projected to make wildfires more frequent and intense, with **extreme fires increasing by up to 14% by 2030, 30% by 2050**, and 50% by the end of the century.

4. Canada's 2023 wildfire season was the most destructive on record, **with fires consuming about 16.5 million hectares** — more than double the previous record.

3.Source: UNEP / GRID-Arendal wildfire report

4.Source: Canadian Climate Institute / Natural Resources Canada summary



“Climate change is not only a rise in temperature — it is a long-term disruption of the systems that shape our weather, water, food, ecosystems, cities, and daily life.”

Climate Change

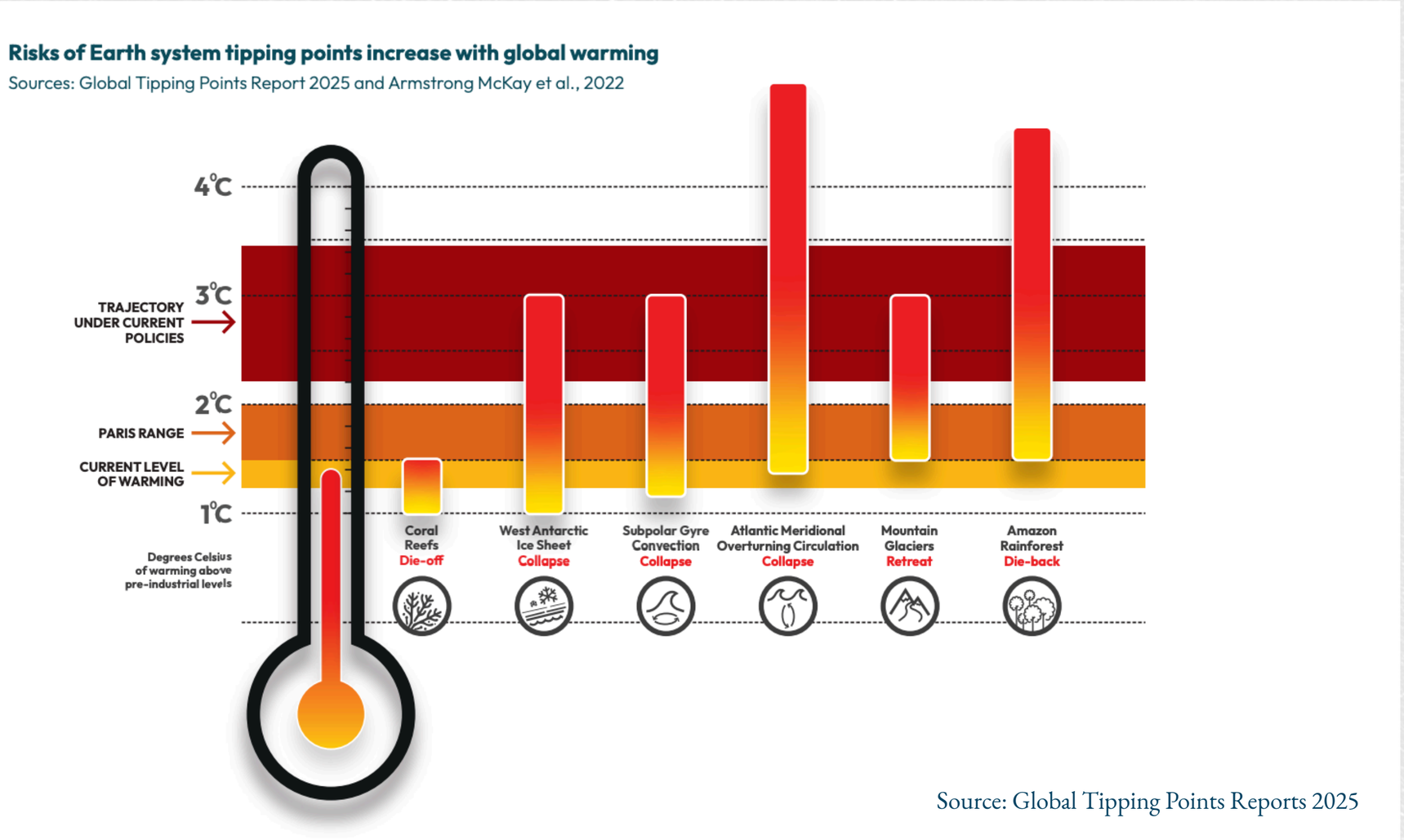






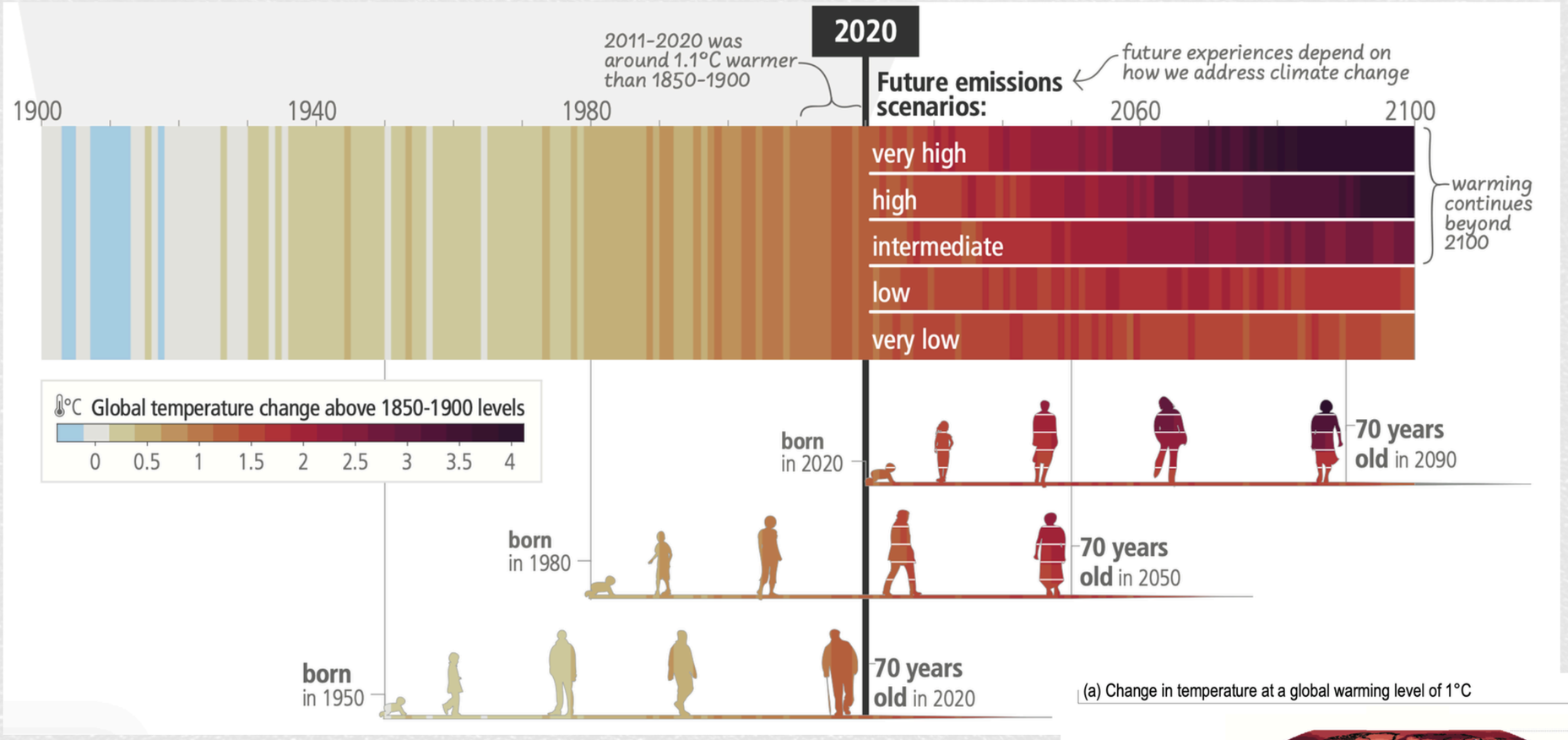
What is Global Warming?

Global warming refers to the long-term heating of Earth's surface observed since the pre-industrial period, primarily caused by human activities such as burning fossil fuels, which releases greenhouse gases that trap the sun's heat.

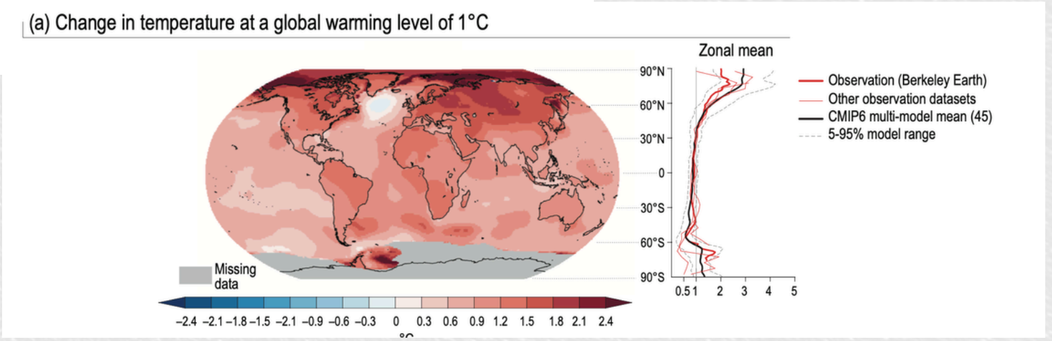


Source: Global Tipping Points Reports 2025

How does our future look?

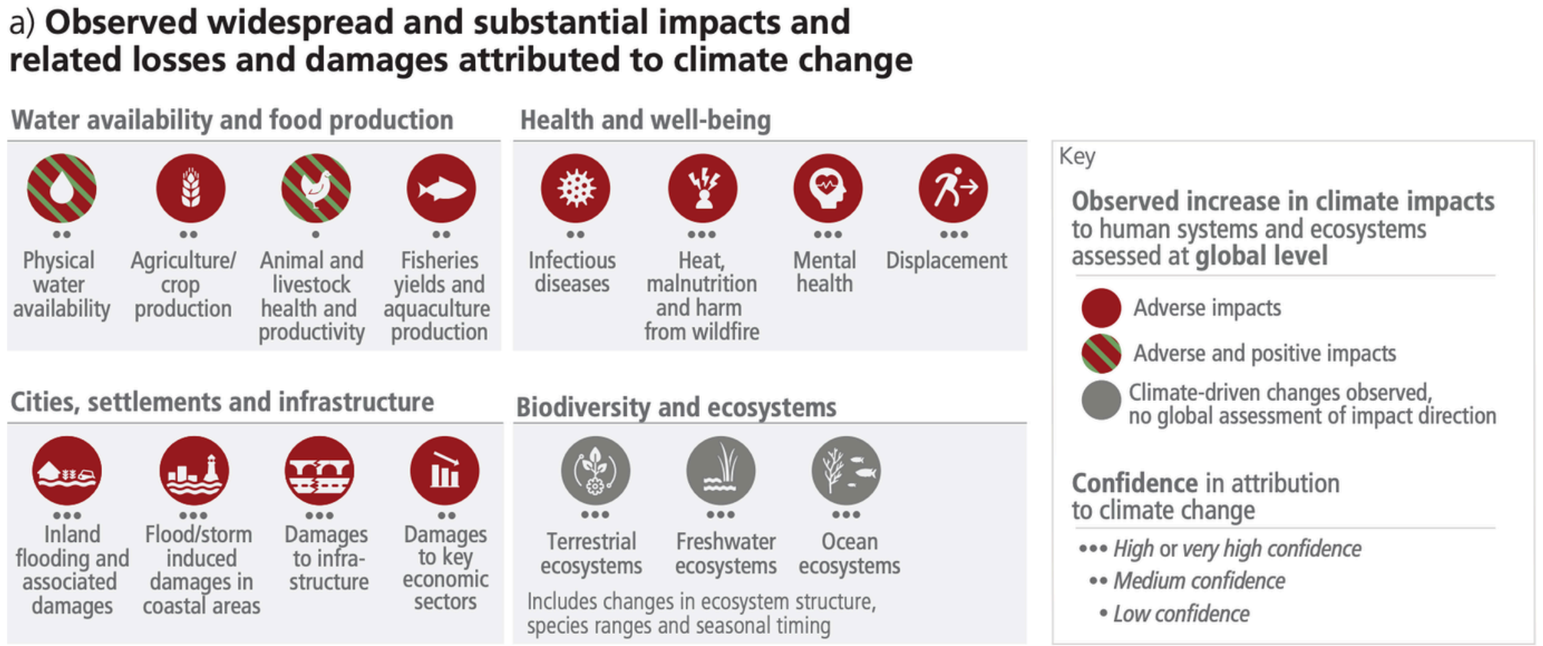


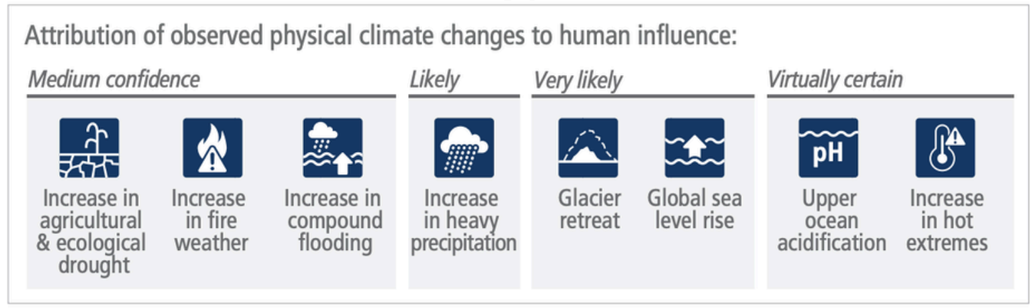
Source:IPCC, CLIMATE CHANGE 2023 Synthesis Report Summary for Policymakers



Source: IPCC, CLIMATE CHANGE 2023 Synthesis Report Technical Summary

Adverse impacts from human-caused climate change will continue to intensify





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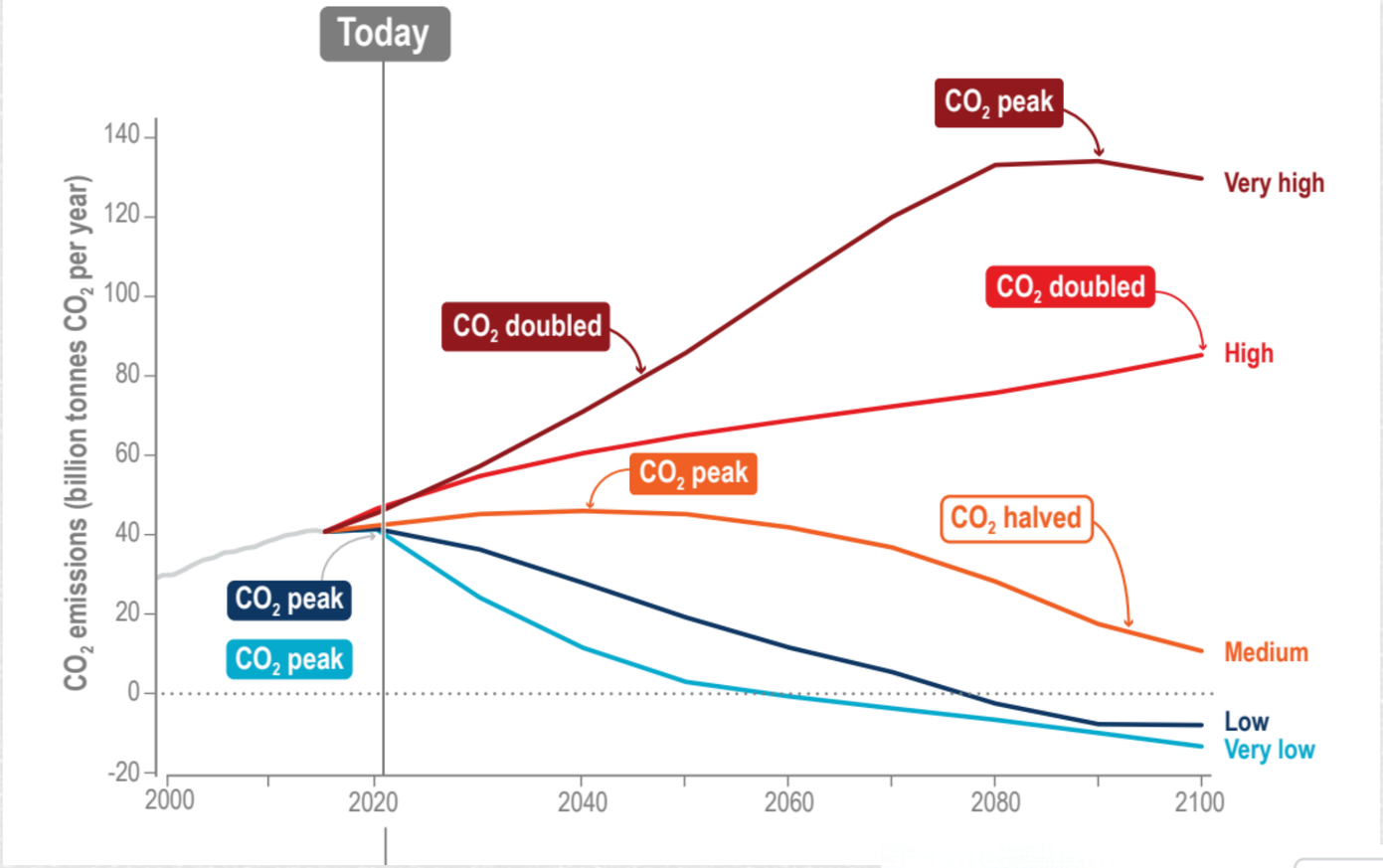
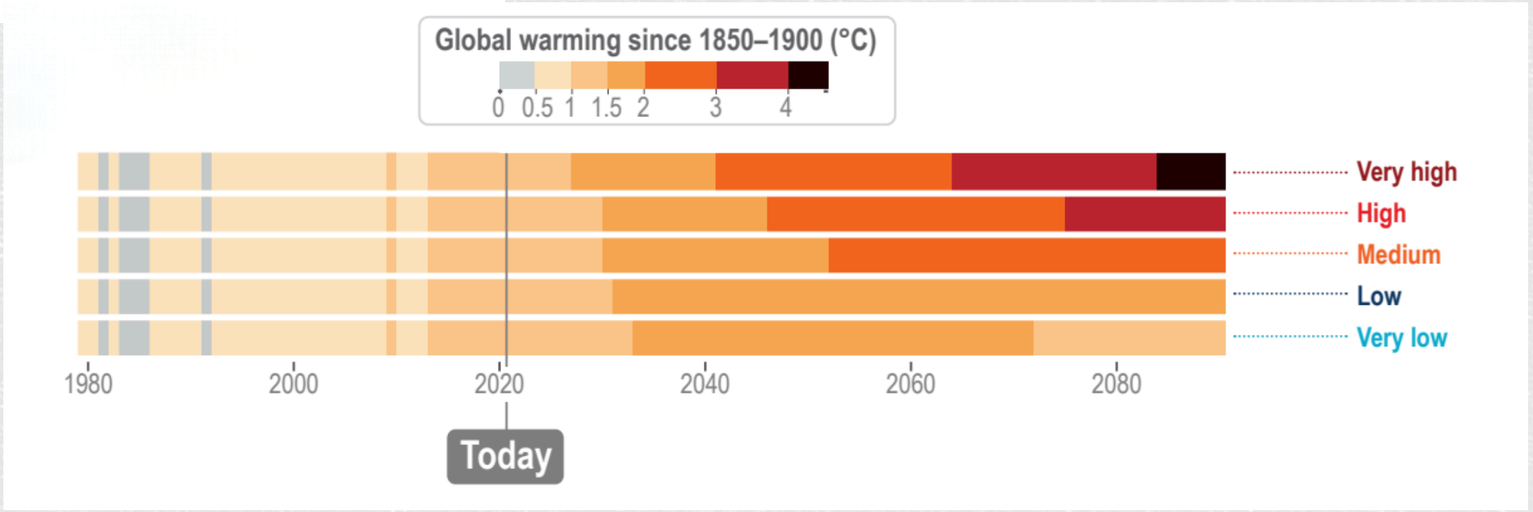


"Emissions Pathways: different social and economic developments can lead to substantially different futurte emussions of CO_2, other greenhouse gassses and air pollutans for the rest of the century."

"For temperature to stabilizie, CO_2 emissions need to reach to net zero"



Source: IPCC, CLIMATE CHANGE 2023 Synthesis Report Technical Summary

What Happens When We Act Too Late

Figure ES.5 Global GHG emissions under different scenarios and the emissions gap in 2030 and 2035

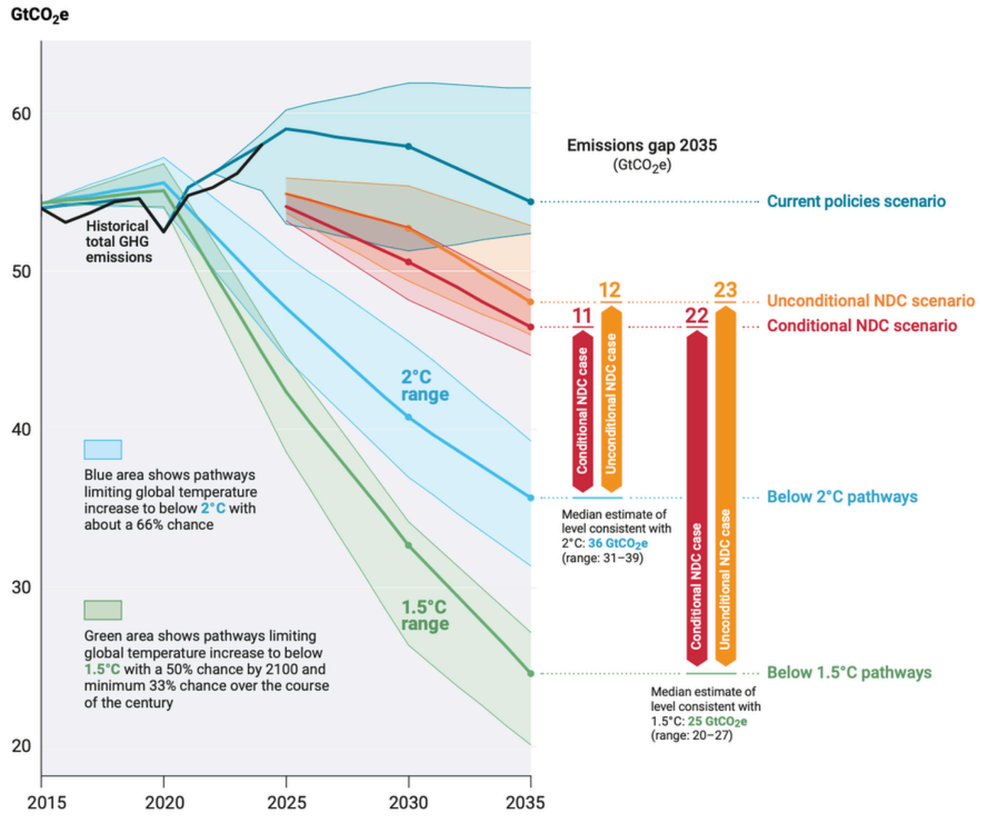
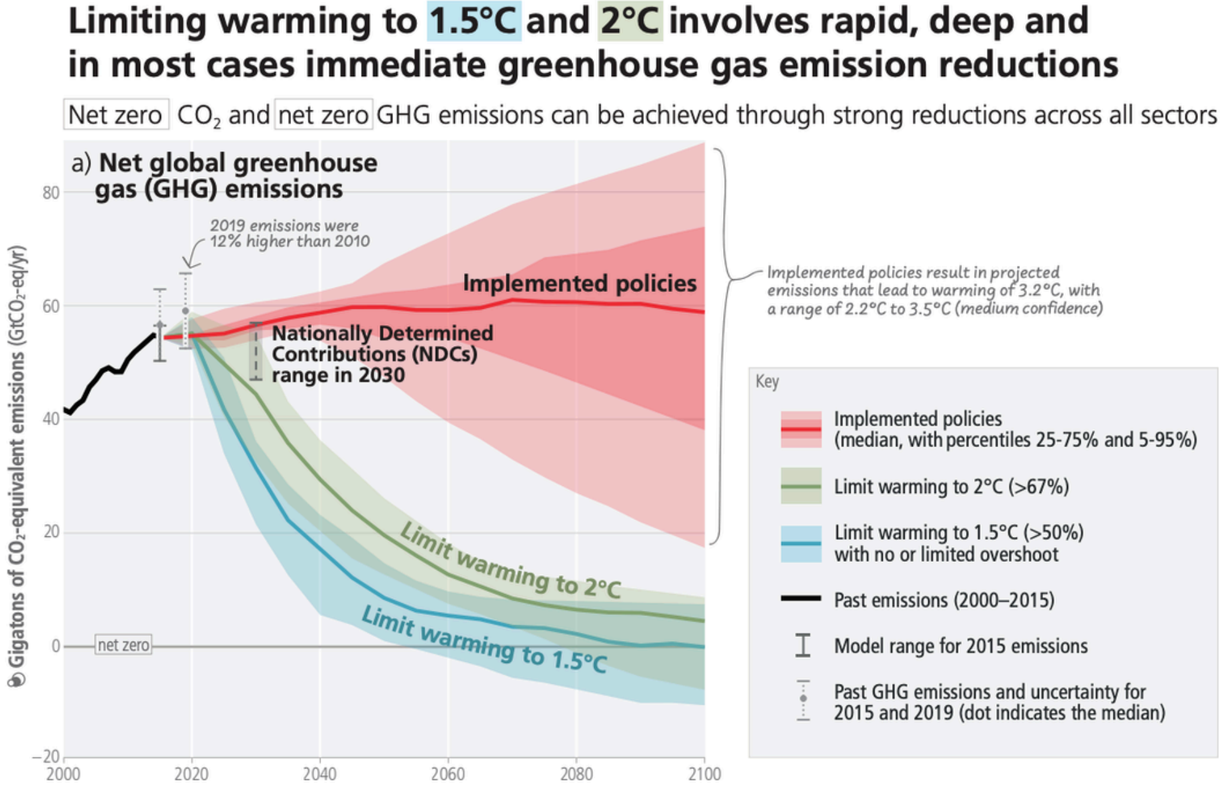


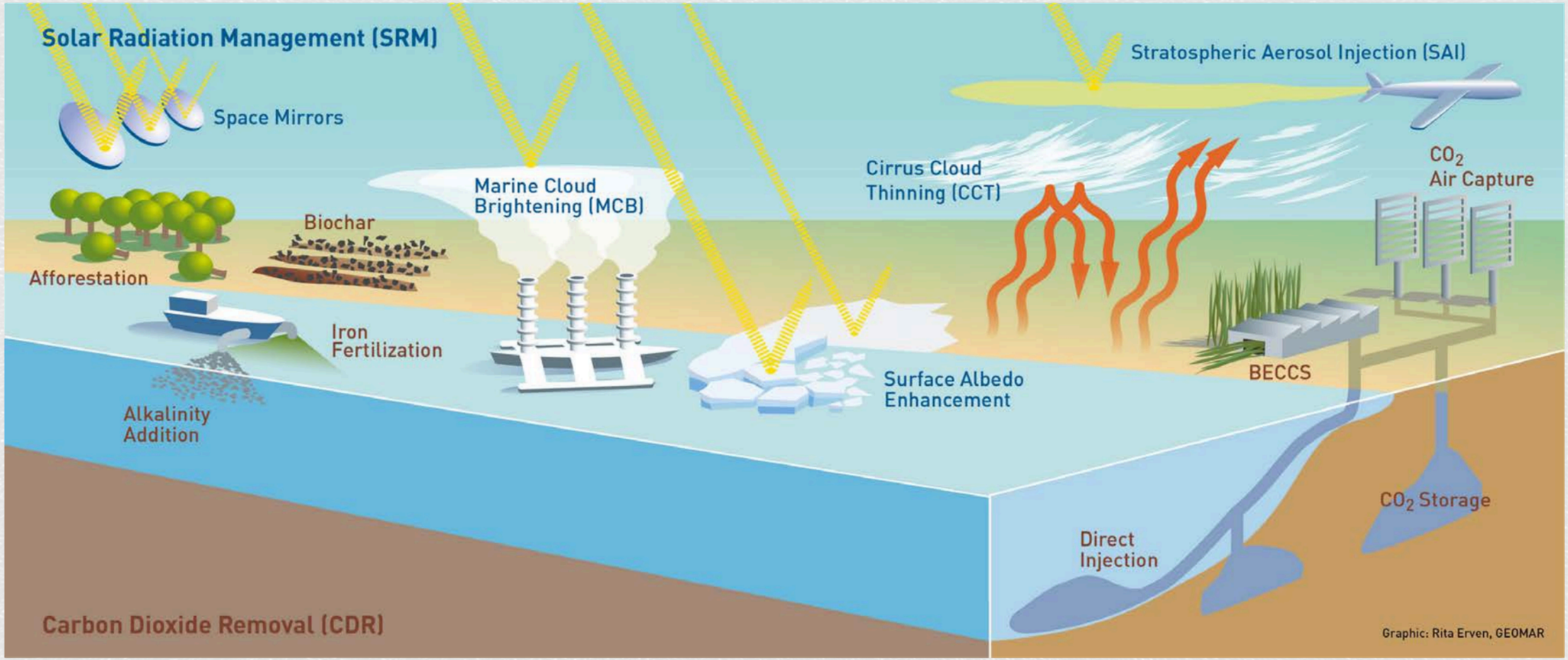
Table ES.2 Global total GHG emissions in 2030, 2035 and 2050, and global warming characteristics of different scenarios, consistent with limiting global warming to specific temperature limits



Source:IPCC, CLIMATE CHANGE 2023 Synthesis Report Summary for Policymakers

Climate Intervention

"Climate intervention (aka, geoengineering, solar radiation modification (SRM)) is cooling the Earth by human means to offset the warming and other impacts due to greenhouse gas accumulation."



Source: Montreal Protocol 45th Open Ended Working Group Side event presentation Bangkok, Thailand July 2023



Our Impact

“Life on Earth Is Not Distributed the Way We Imagine”

Life on Earth
an inventory of biomass



the six kingdoms

Each cube represents the biomass of a kingdom. Most of the biomass is found in plants. Bacteria and archaea are micro-organisms most of which are located in deep subsurface environments. Protists are micro-organisms found in almost any environment that contains liquid water. Fungi and animals are heterotrophs: they feed on other living organisms.

Viruses are made up of organic material but are technically not alive. Being tiny, they are abundant in many environments, despite having a small contribution to the total biomass.

the rise of livestock

Human activity has significantly amplified livestock biomass through centuries of breeding, husbandry, and industrial agriculture, resulting in a substantial increase in the global population of domesticated animals raised for various purposes, including food and resources.

the animal kingdom

Animals are mainly marine, dominated by fish and arthropods. We find an abundance of life underground (terrestrial arthropods, nematodes and annelids). Wild mammals comprise only a tiny fraction, smaller than 1%, of the animal biomass. Today, humans weigh about 10 times more than all wild mammals. To generate enough proteins, humans have created livestock that now weighs almost twice the entire world population.

biocubes.net

© Ménard & Shtarkman

data from Bar-On, Phillips, Milo, PNAS (2018)

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The Technomass

the ingredients of man-made structures

a rapid increase

These cubes represent the mass of the main types of materials used in man-made structures all around the world. The tick marks show how much mass was added since 1900 and 1990. Most of this mass was added during our lifetime.

The red cube represents the mass of all humans.



biocubes.net

© Ménard & Shtarkman

data from Elhacham, Ben-Uri, Grozovski, Bar-On, Milo, Nature (2020) and Ritchie, Roser, ourworldindata.org (2018)

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The Living vs. The Built



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What can we do as developers, builders, architects, designers and homeowners?

EMIT LESS

Reduce embodied carbon by replacing high-emitting materials with low-carbon alternatives, and lower operational carbon through smart design.

Passive House

Net-Zero Housing



CO_2 – – = CO_2

HIGHER EMISSIONS

REDUCED ENERGY DEMAND

CLEAN ENERGY ON-SITE

LOWER EMISSIONS



SMART DESIGN. LOWER EMISSIONS.

STORE MORE

Store carbon through biogenic and recycled-content materials, locking it into buildings for decades.



REGENERATIVE BY DESIGN. A POSITIVE LEGACY.

Key Terminalogy

1



Carbon Emissions

The release of greenhouse gases, such as CO_2, into the atmosphere.

2



Operational Carbon

Emissions from the energy used to heat, cool, light, and operate a building.

3



Embodied Carbon

Emissions linked to materials across their life cycle – extraction, manufacturing, transport, construction, and end of life.

4



Carbon Footprint

The total greenhouse gas emissions associated with a person, product, building, or activity.



Key Terminalogy

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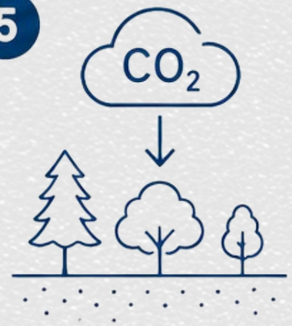

Carbon Removal

The process of taking CO_2 out of the atmosphere and storing it durably in natural or engineered systems.

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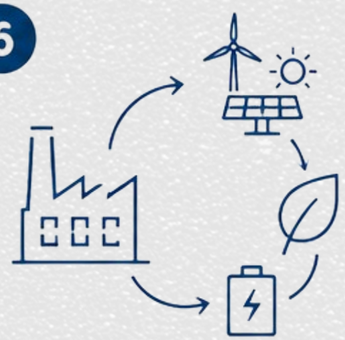

Decarbonization

The transition to lower emissions by reducing or eliminating carbon from energy, materials, buildings, and industry.

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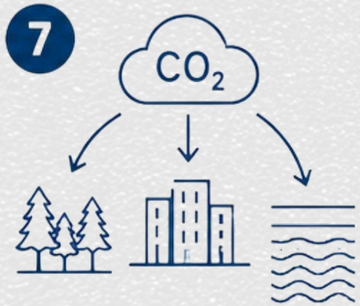

Carbon Storage / Sequestration

The capture and long-term storage of carbon in forests, soils, buildings, or underground formations.

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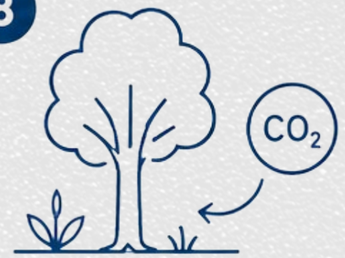


Biogenic Carbon

Carbon absorbed and stored by plants and other biological materials through photosynthesis.





Source: Azure Magazine Mar 2, 2023, Architects Richard Unterthiner and Geoffrey Turnbull

Passive House

"Passive House is a high-performance building standard focused on exceptional energy efficiency, comfort, health, and durability.
Passive House buildings make efficient use of passive heating and cooling sources and are designed to provide high indoor comfort with very low energy demand."

Source: Passive House Institute / International Passive House Association, What is a Passive House?

To be certified, Passive House buildings must meet strict performance criteria, including:

Space heating demand: max. 15 kWh/m²/year
Heating load: max. 10 W/m²
Airtightness: max. 0.6 air changes/hour at 50 Pa
Total primary energy demand: max. 120 kWh/m²/year

Source: Passive House Canada, The international Passive House Standards

How Passive House Works?



1. High-Performance Envelope

Well-insulated walls, roof, and floor reduce heat loss and heat gain.



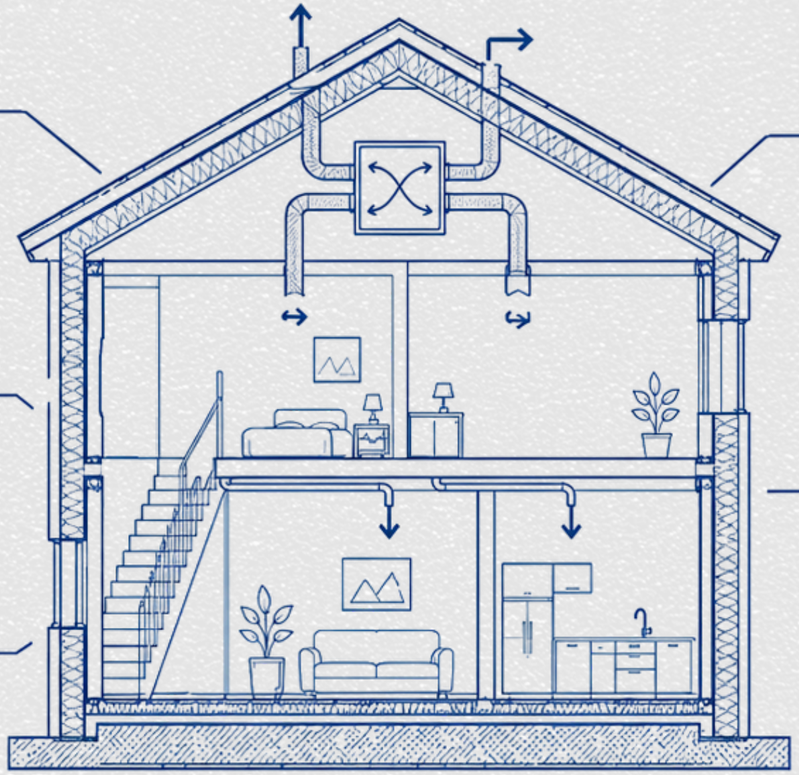
2. Airtightness

A continuous air barrier minimizes uncontrolled air leakage.



3. High-Performance Windows

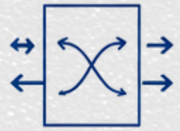
High-quality glazing and frames improve comfort and efficiency.





4. Thermal-Bridge-Free Design

Careful detailing prevents heat from bypassing the insulation layer.



5. Heat Recovery Ventilation

Balanced ventilation supplies fresh filtered air while recovering heat from exhaust air, improving comfort and indoor air quality.

Ultra-low energy. High comfort. Healthy indoor environment.



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“One performance standard, adaptable across building types, climates and constructions methods”

New construction

Single-family homes, multi-residential buildings, schools, offices, and commercial buildings



Putman Family YWCA
Mixed-Use
Affordable Housing
Hamilton, ON
Kearns Mancini
Architects Inc.



Salmon Stone
Childcare Centre
Vancouver, BC
Francl Architecture



Harmony Commons at
the University of
Toronto
Scarborough, ON
Handel Architects LLP



Trappers Trail Passive House, Haliburton, ON
Contactor:Igor & Darya Krapchatova

Existing buildings

Deep energy retrofits using Passive House components and EnerPHit retrofit standards.

500 MACNAB **1967**



500 MACNAB **2020**



Ken Soble Tower (Built in 1967)
ERA Architects

Located at 500 MacNab Street North, Hamilton, Ontario, Canada
146 units of modernized affordable seniors' housing

Completion in 2020

Ultra-low energy use:

- 94% reduction of greenhouse gas emissions compared to the existing building
- At its peak, the total energy needed to heat or cool each unit will be equal to the energy needed to run 3 incandescent light bulbs (100W).

Different Climates

Cold, hot, and mixed climates – with strategies adapted to local conditions.



Residencial Basa de la Mora III, multi family dwelling in Zaragoza, SPAIN
GRUPO LOBE



KSAT Dubai Space Center (Mohammed Bin Rashid Space Centre)
Casetta & Partners

Different Construction Methods

Passive House is not limited to conventional construction.
It can be achieved with different systems, including straw bale, prefab panels, modular construction, mass timber, and hybrid assemblies.



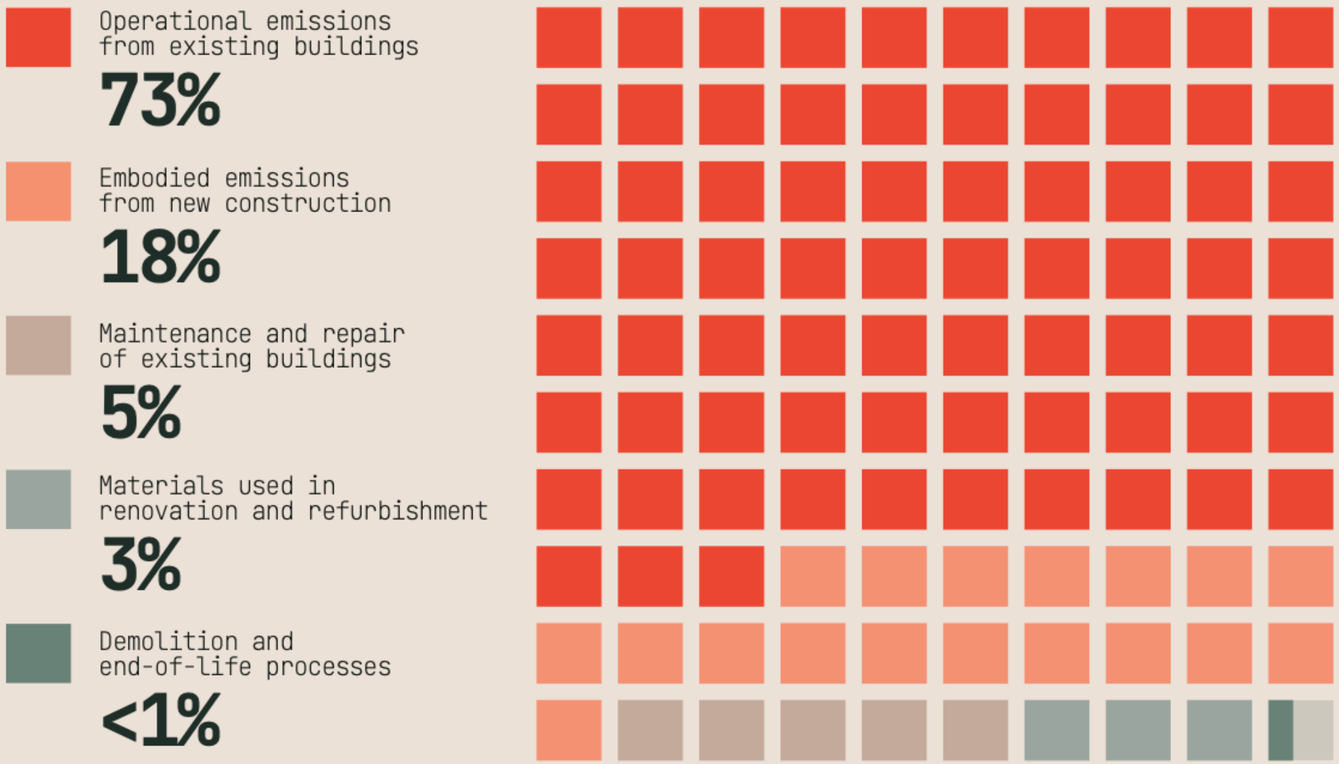
Straw Bale Passive House,Peterborough, ON
Builder:Straworks



City Housing Hamilton, 1620 Main Street East, Hamilton, ON
Architects: Mc Callum Sather

Why Passive House Principles Matter

Figure 4.
CO_2 Emissions by building source



Source: The Housing We Need For The Future We Want, Greenpaper, July 2026

"The roughly 1% of the stock added new each year generates 18% of the annual building stock emissions in the EU, while the remaining 99% of buildings account for around 82% of building stock's annual emissions. This brings to light two key realities: new construction is disproportionately carbon-intensive, while the existing stock remains the dominant source of ongoing emissions."

Source: Eurropean Union Commission(2026): Supporting life-cycle approaches to decarbonise European Buildings

Passive House Is a Shift in How We Build

“It is not ordinary but it has to be”

- A shift from standard to **performance-focused** construction
- Builds **energy-efficient**, comfortable, and climate-resilient buildings
- Reduces energy demand through better envelope performance and airtightness
- Requires better coordination between design, trades, materials, and execution
- Prefab and modular systems can improve quality, precision, and performance
- Better performance should become the baseline, not the exception

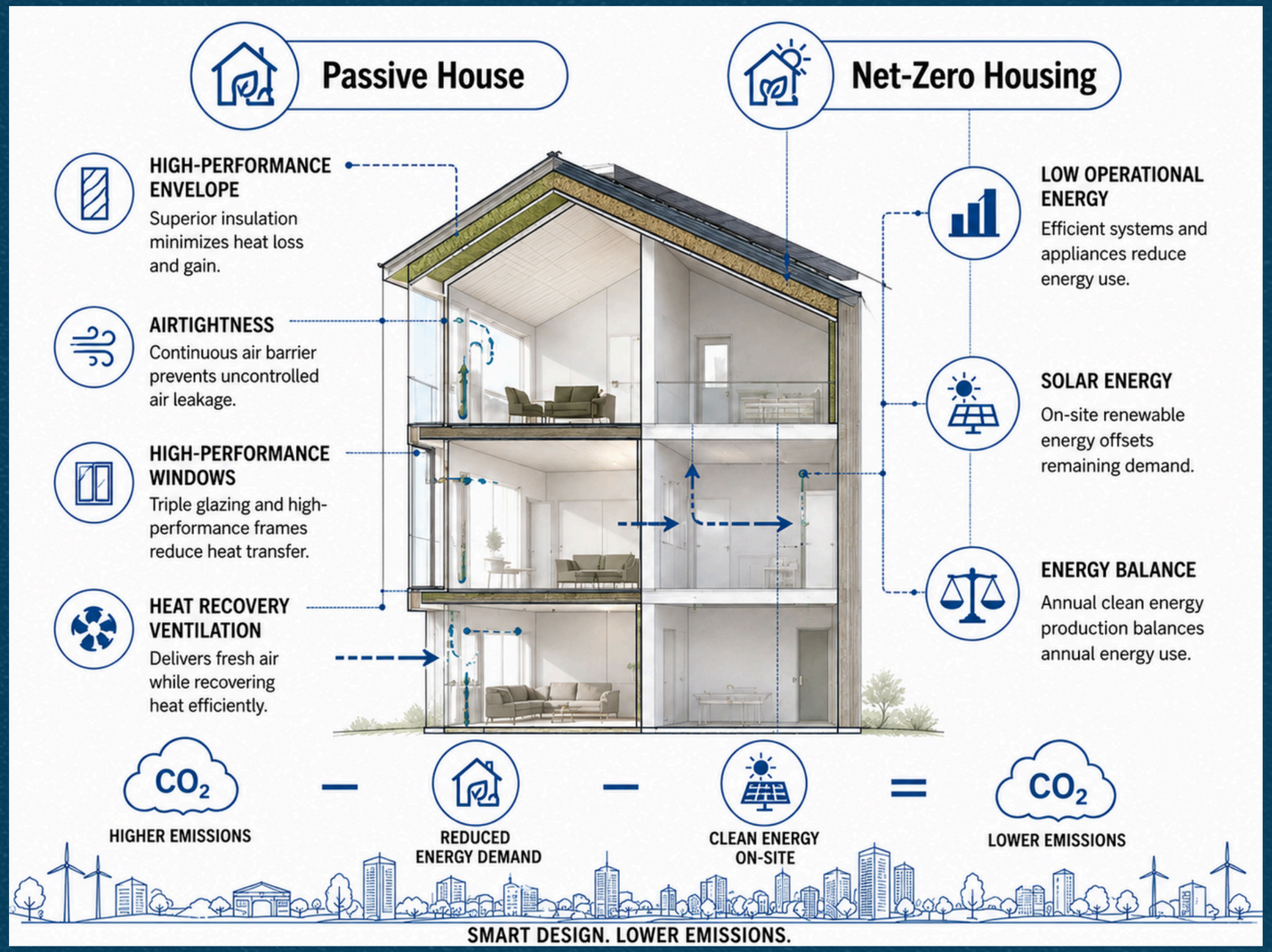


The challenge is **whether we choose to make better performance the baseline**.

From Passive House to Net Zero

Passive House focuses on reducing energy demand first.
Net Zero focuses on balancing the energy a building uses with the energy it produces or offsets.

The connection is simple:
The less energy a building needs, the easier it becomes to reach Net Zero.

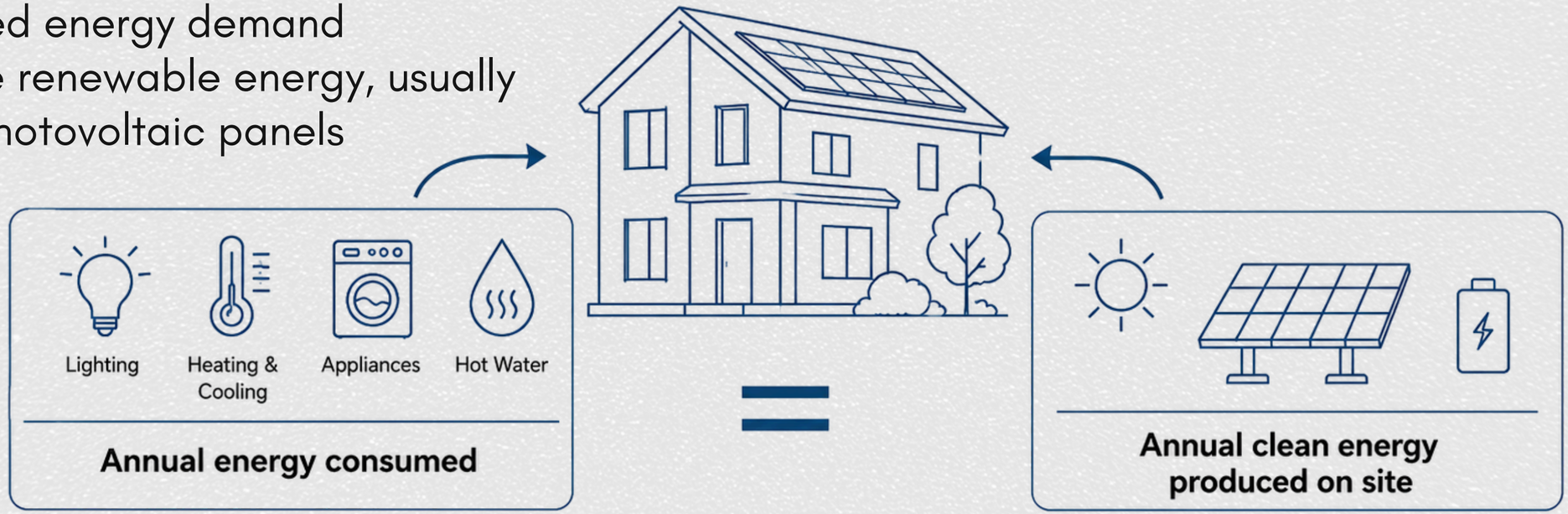


What Is Net-Zero Housing?

A Net-Zero Energy home produces as much clean energy as it consumes over the course of a year. It starts with a highly efficient building:

- High-performance envelope
- Airtight construction
- Efficient heating, cooling, ventilation, lighting, and appliances
- Reduced energy demand
- On-site renewable energy, usually solar photovoltaic panels

Efficiency first. Renewable energy second. The goal is an annual energy balance:
Energy used = clean energy produced



Net Zero Is Not the Same as Low Carbon

Net-Zero Energy **focuses on operational energy**:
How much energy does the building use and produce each year?
But a building can achieve Net Zero Energy while still having **significant embodied carbon** from.



Operational success does not erase embodied impacts.

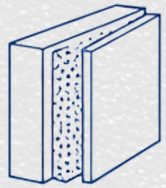
A truly carbon-conscious building

Low operational carbon

through energy efficiency and clean energy



Efficient building performance



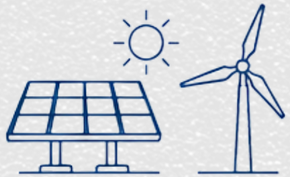
Insulation & energy efficiency



Heating & cooling efficiency



Lighting efficiency



Clean energy (solar & renewables)



Low embodied carbon

through better material choices, reuse, durability, and bio-based materials



Low-carbon materials



Reuse & recycling



Long-life, durable design



Bio-based materials



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Why Materials Matter

"Much of a building's embodied carbon is decided before construction even begins."

Every design decision carries a material consequence:

- What we build with
- How much we use
- Where it comes from
- How it is manufactured
- How far it travels
- How long it lasts
- What happens when it is replaced or removed

Material choices are not only aesthetic or functional decisions.
They are carbon decisions.

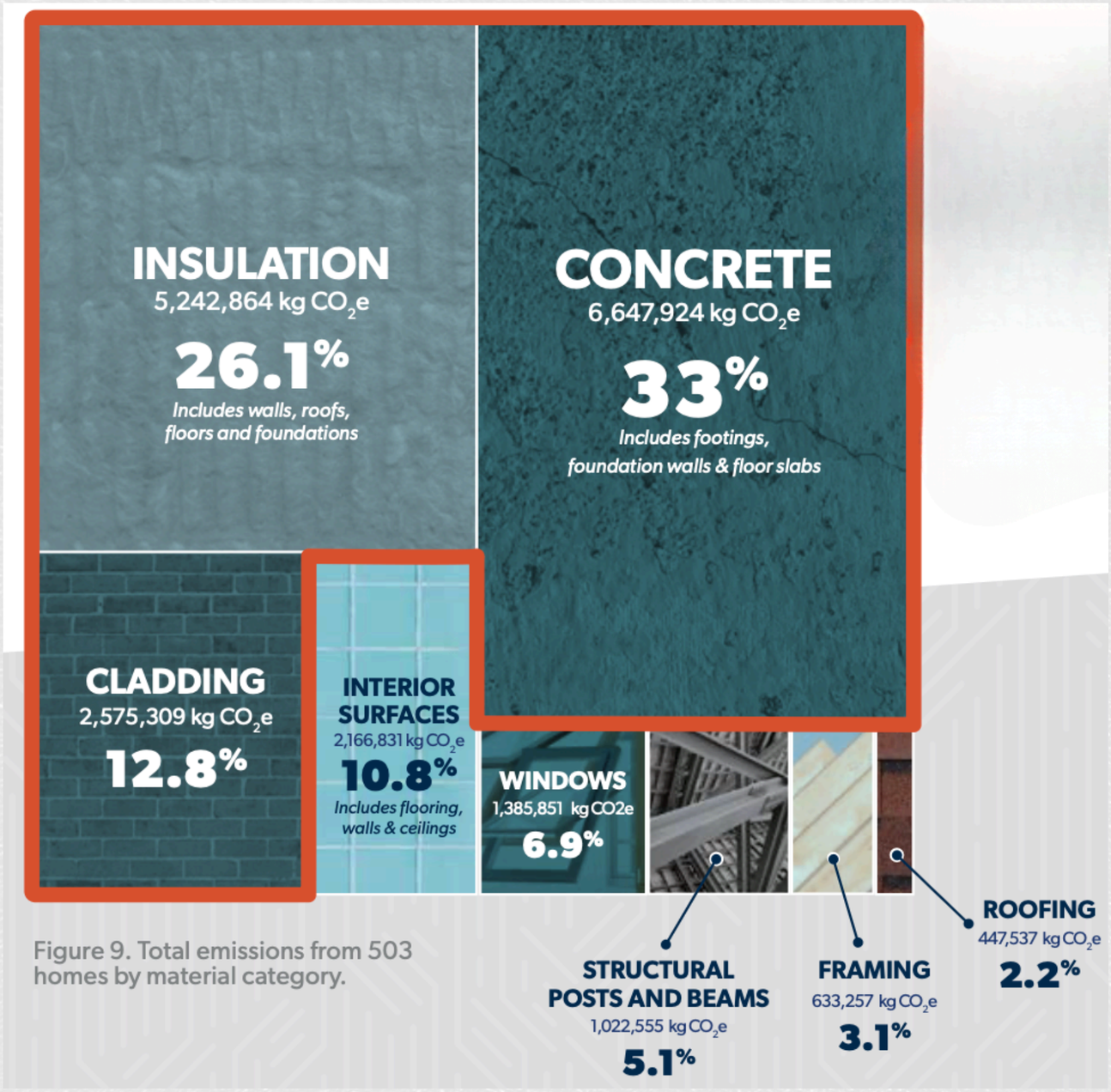


Figure 9. Total emissions from 503 homes by material category.

Material Analysis

"72% of total Material Carbon Emission from just three material categories!"

Source: Builders for Climate Action & Passive Buildings Canada • Emissions of Materials Benchmark Assessment for Residential Construction

Low-Carbon Design

Low-carbon design is not defined by one label or one perfect product.
They are selected by looking at the **full material story**:



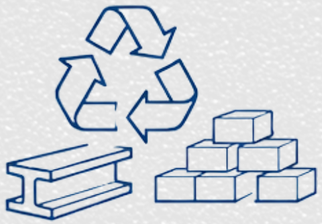
Bio-Based Materials

Renewable materials such as wood, straw, hemp, cork, linoleum, and mycelium that can reduce emissions and, in some cases, store biogenic carbon.



Engineered Low-Carbon Materials

Products designed to reduce emissions through improved manufacturing, recycled content, lower-impact binders, renewable energy, or optimized material use.



Reuse and Recycled Content

Keeping existing materials in use and reducing demand for virgin extraction and manufacturing.



Durability and Long-Life Design

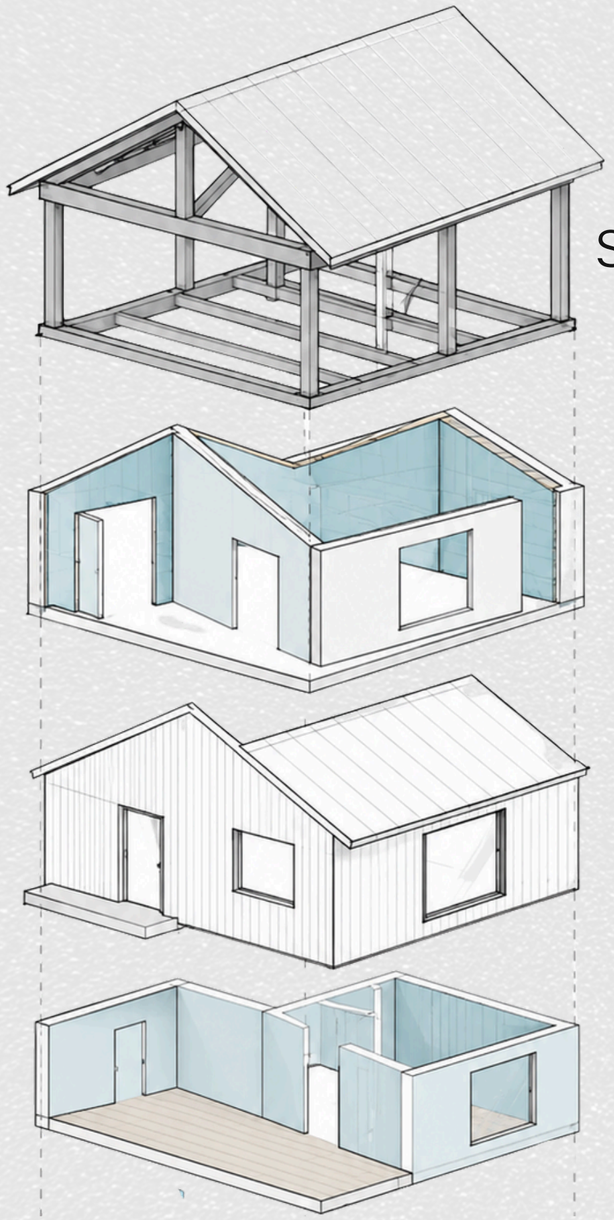
Choosing materials that last, can be repaired, adapted, maintained, and kept in service longer.



Material Comparison Tools and Documents

Using EPDs, Declare labels, life-cycle assessment data, and material libraries to make more informed decisions.





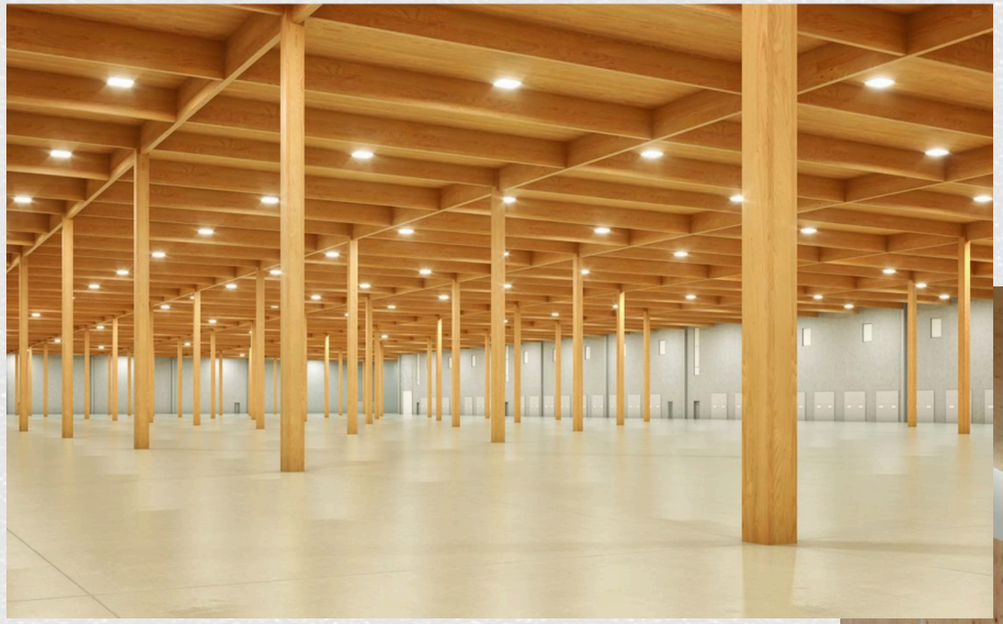
Low-carbon choices can be made across every layer of a building.

From structure and insulation to cladding, interior finishes, systems, and long-term maintenance, each layer offers an opportunity to:

Use less
Choose lower-impact materials
Reuse what already exists
Store carbon where possible
Design for a longer life

Low Carbon Structure Design

Mass Timber: CLT & Glulam & LVL



The primary structure often represents a large share of a building's embodied carbon.
Engineered wood systems that can replace some concrete or steel applications while storing biogenic carbon for the life of the building.



Efficient light-frame systems that use less material and can be paired with wood-fibre, cellulose, hemp, or straw insulation.

Source: elementfive.co

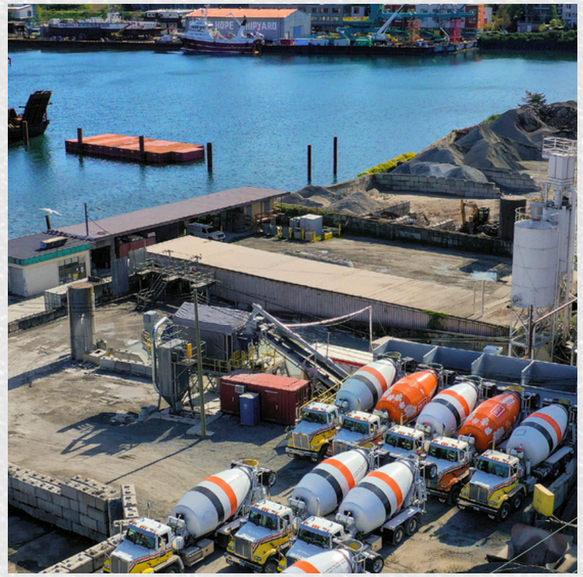
Low-Carbon Concrete

Concrete mixes that reduce Portland cement through supplementary cementitious materials, optimized mix design, recycled aggregates, or emerging carbon-mineralization technologies.

- Lafarge ECOtect™ — lower-carbon ready-mix concrete
- CarbiCrete — cement-free concrete masonry / CO_2 mineralization
- CarbonCure — CO_2-mineralized ready-mix technology
- PyroTech BioCrete— Carbon Sequestration with Biochar Concrete

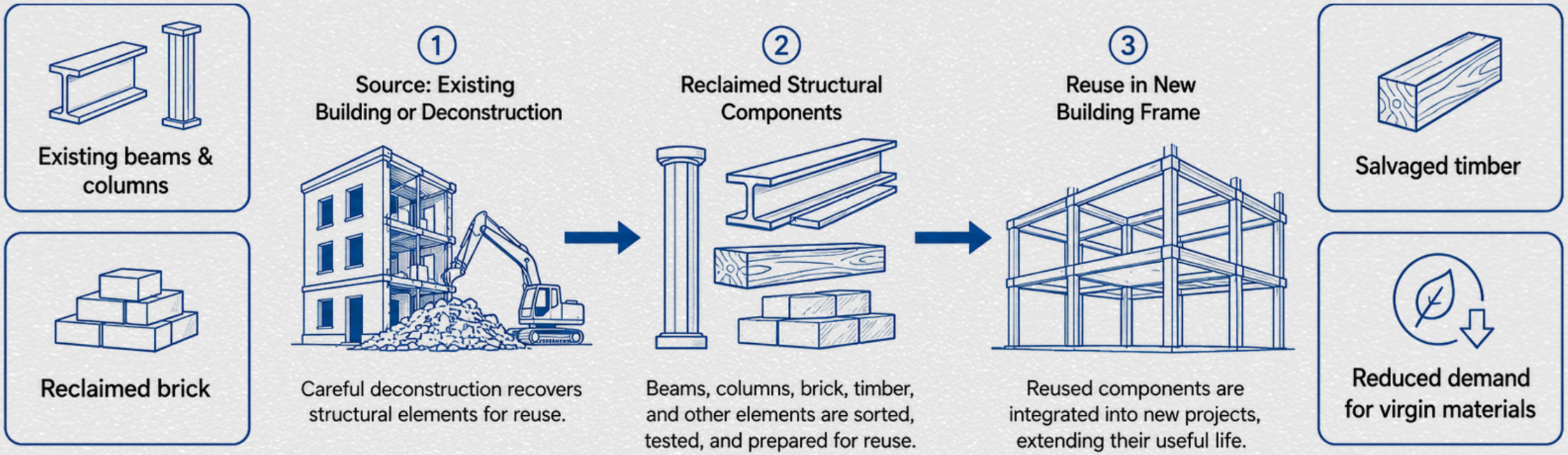








Reused Structural Components



At the scale of a building, reuse can preserve not only material and character — but also a significant amount of embodied carbon.

It is similar to thrifting and restoring a well-made piece of furniture:

- See the value in what already exists
- Repair, reinforce, refinish, or adapt it when possible
- Avoid replacing quality materials simply because they are old

Low Carbon Insulation



Source:climatizer.ca

Low-carbon insulation can be made from recycled paper, wood fibre, agricultural residues, rapidly renewable plants, and recycled mineral materials.

Bio-Based & Recycled Insulation Materials

- Cellulose insulation
- Recycled-content mineral wool
- Recycled-content fibreglass
- Wood-fibre insulation
- Hemp insulation / hemp wool
- Straw bale insulation
- Prefabricated straw panels



Source: savick.ca



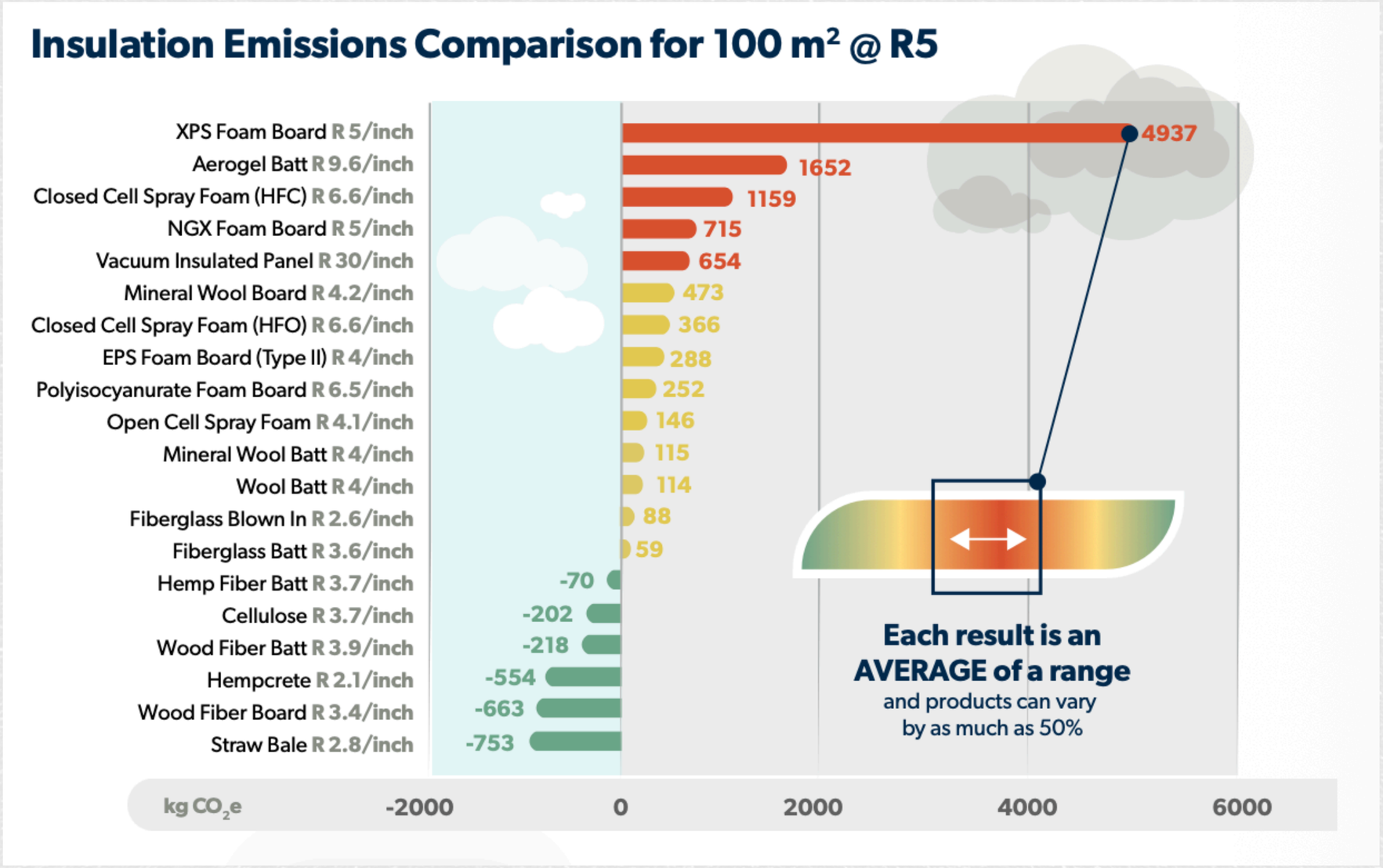
Source: wood100.ca

Choose based on:
Climate • fire safety • moisture management • assembly design • local availability • verified product data



Source: atlantichemp.ca

How Much Difference Can Insulation Choices Make?



Carbon Storing Materials
Youtube Video
Builders For Climate Action

Source: Builders for Climate Action & Passive Buildings Canada • Emissions of Materials Benchmark Assessment for Residential Construction

Low-Carbon Exterior Cladding

Exterior cladding can reduce carbon through renewable materials, reuse, recycled content, durability, and verified product data.



Source:arcanamaterials.co

- Wood → renewable / potentially carbon-storing
- Reclaimed Brick and stone → reuse what already exists
- Recycled Metal → recycled content and long service life
- Engineered surfaces → durability and verified environmental aspects



Source:arcanamaterials.co



Source:cosentino.com

Choose based on: Embodied carbon • durability • repairability • local availability • climate performance • verified product data

How Much Difference Can Cladding Choices Make?

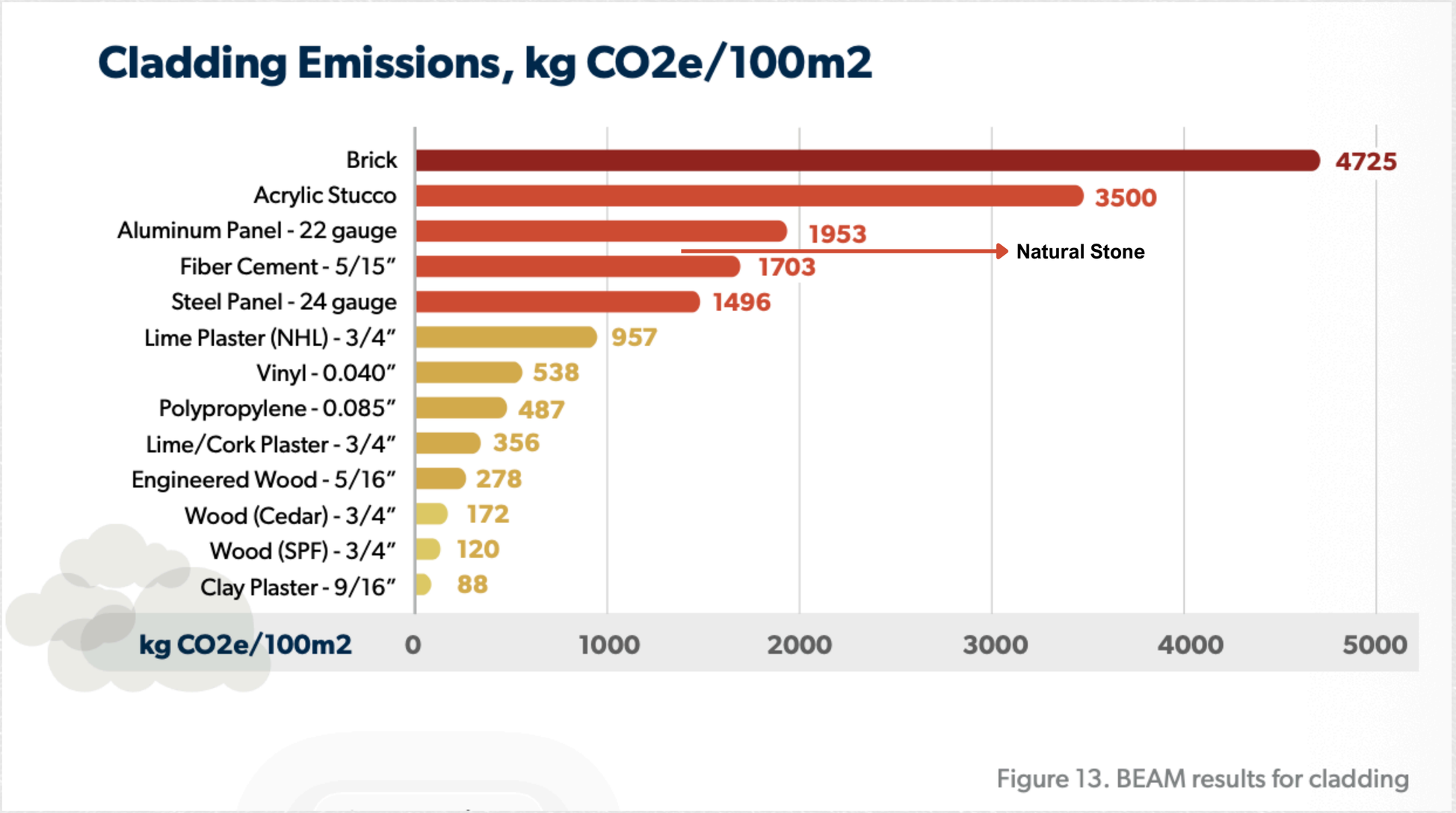


Figure 13. BEAM results for cladding

Source: Builders for Climate Action & Passive Buildings Canada • Emissions of Materials Benchmark Assessment for Residential Construction

Dekton for Complex Façade Applications

A durable engineered surface for projects where façade performance, code requirements, and architectural expression all matter.

Well suited for:

- Retrofit and recladding projects
- Commercial and institutional buildings
- Mid-rise and high-rise façades
- Hospitality, retail, and public-facing buildings
- Ventilated rainscreen façade systems
- Projects requiring large-format visual continuity
- Buildings exposed to demanding weather, UV, moisture, and freeze-thaw cycles









Dekton offers a façade option where durability, low maintenance, fire-performance requirements, large-format design, and varied aesthetic preferences need to work together.

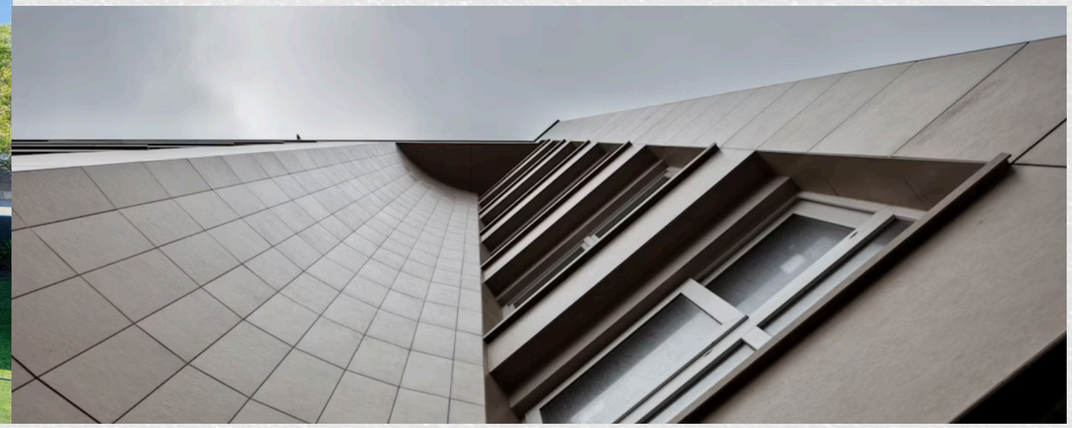
+ Cradle-to-Grave Carbon Neutral

Dekton’s Technical Performance for Long-Term Durability





- High Density
- Flexural Strength
- Dimensional Stability
- Very Low Porosity
- Thermal Performance
- Fire & Heat Resistance
- UV, Scratch & Abrasion Resistance



Low Carbon Interior Finishes

- Linoleum and cork flooring
- Responsibly sourced or reclaimed wood flooring
- Clay and lime plaster finishes
- Low-VOC mineral paints and limewash
- Recycled-content, or low-emitting millwork materials
- Durable engineered surfaces with verified product data



Source: forbo.com



Source:corkstore.ca



Source:www.keim.com

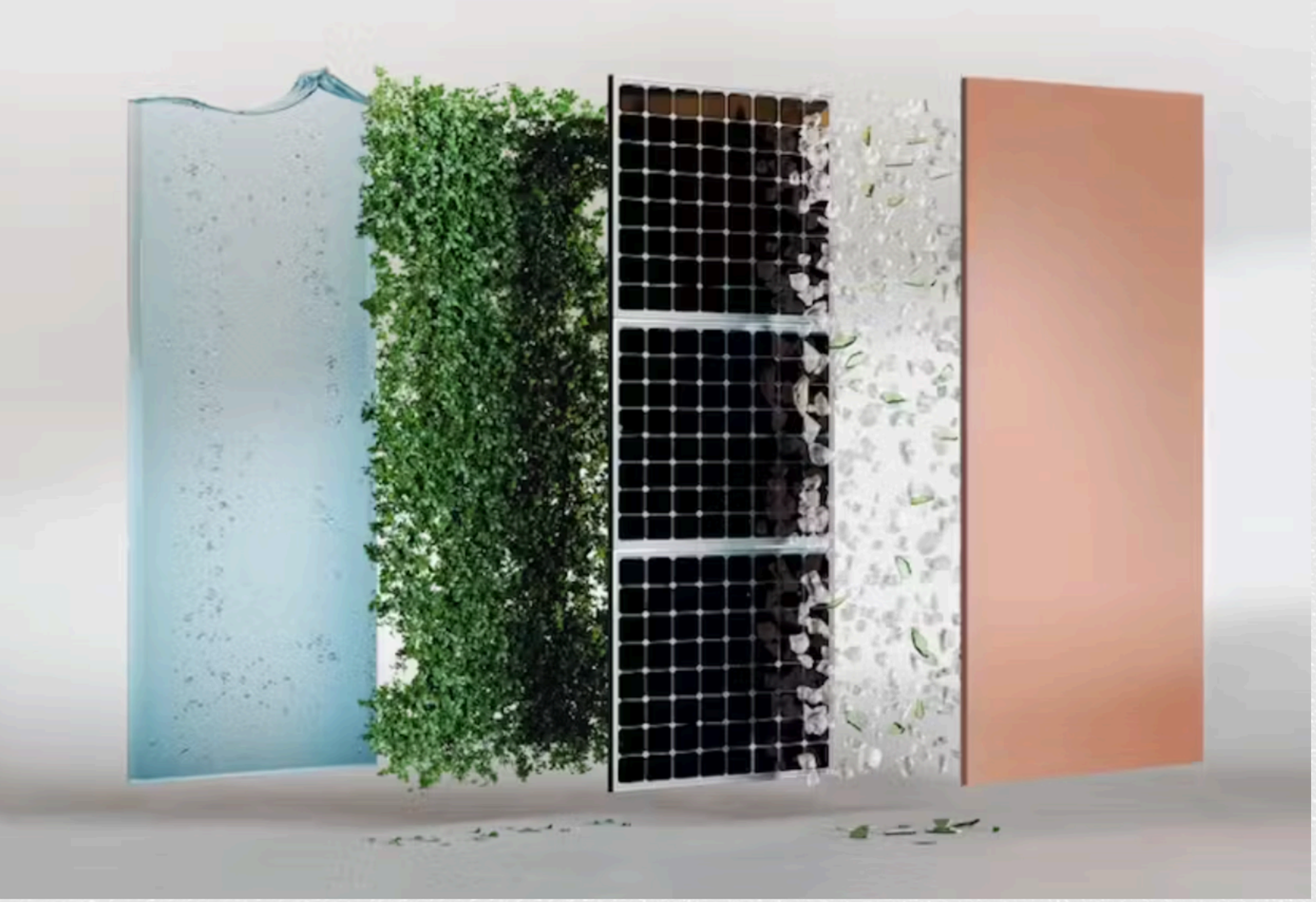


Source:www.keim.com

Choose based on: Low embodied carbon • healthy indoor air • durability • repairability • recycled or bio-based content • verified product data

Choosing Better Engineered Materials

Not every application allows for carbon-storing materials.



When sourcing look for:

Transparent data

Lower-impact production

Durability

Full life-cycle responsibility

Dekton for Carbon-Conscious Interiors

Cosentino Sustainability Website

A durable surface for high-use spaces—designed to perform beautifully over time.

Cradle-to-Grave Carbon Neutral
Dekton offsets 100% of its CO_2 emissions across its full product life cycle.



One Surface, Multiple Applications

- Kitchen countertops and islands
- Bathroom walls, vanities, and shower surfaces
- Fireplace surrounds and feature walls

(I hope you choose an electric one!)

- Flooring and stair surfaces
- Furniture, tables, and custom millwork

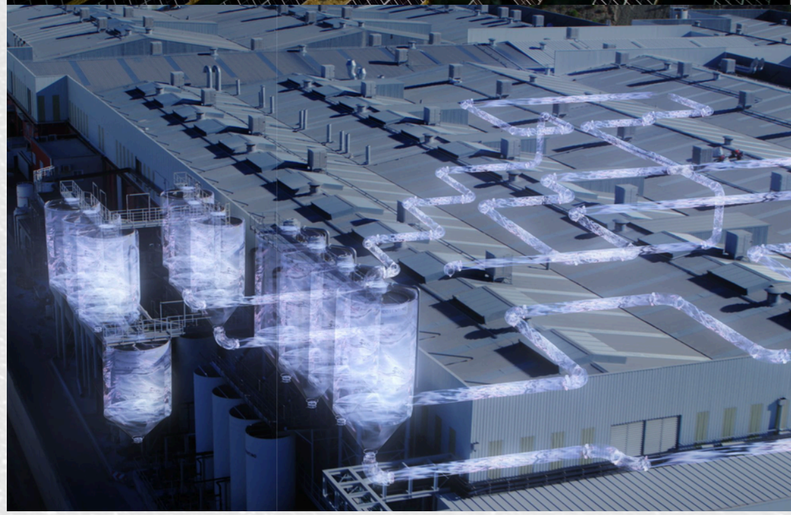
Designed for Long Life

UV resistant • stain resistant • scratch resistant • low water absorption • low maintenance • large-format design continuity

Dekton®: Key Sustainability Strategies

- **Renewable Electricity**
- **Water Recovery & Reuse.**
- **Recycled & Recovered Materials**
- **Waste & Dust Recovery**
- **Energy Efficiency & Heat Recovery**
- **Transparent Environmental Documentation**







Dekton® is **cradle-to-grave carbon-neutral** Cosentino calculates the product's carbon footprint across its full life cycle, works to reduce emissions through manufacturing improvements, and offsets the remaining emissions.

What to Look For When Choosing Materials

EPD — Environmental Product Declaration
What is the product's life-cycle environmental impact, including global warming potential (GWP)?

Declare Label
Are the ingredients transparently disclosed, and does the product avoid Red List chemicals?

HPD — Health Product Declaration
What is in the product, and are there potential health concerns?

GREENGUARD Gold
Does the product meet strict low-emission standards for healthier indoor air?

FSC Certification
Is wood responsibly sourced and traceable through the supply chain?

Cradle to Cradle Certified®
Has the product been assessed for material health, circularity, climate, water and soil stewardship, and social fairness?

Impacts of material substitutions: high emission home

NET CARBON EMISSIONS [kg CO_2e]	Original model – Highest MCI	BAM Substitutions	BPM Substitutions
FOOTINGS & SLABS	5,793	4,648	3,093
FOUNDATION WALLS	36,805	7,805	2,030
STRUCTURAL ELEMENTS	1,349	1,349	1,349
EXTERIOR WALLS	12,481	-2,265	-9,076
EXTERIOR WALL CLADDING	10,756	1,105	806
WINDOWS	2,325	2,325	1,447
INTERIOR WALLS	702	660	-4,653
FLOORS	4,572	2,346	1,296
CEILINGS	533	437	-1,358
ROOF	1,648	1,276	-7,904
GARAGE	4,546	694	-1,662
NET TOTAL MCE	**81,510**	**20,380**	**-14,632**
NET MCI OF HEATED AREA (kg CO_2e/m^2)	**262.1**	**65.5**	**-47.1**
% CHANGE FROM INITIAL		**-75%**	**-118%**

Tabel 9. Material substitutions for second highest MCI home (based on heated floor area)

"Up to 75 % carbon emission reduction is possible with Best Available Materials"

Source: Builders for Climate Action & Passive Buildings Canada • Emissions of Materials Benchmark Assessment for Residential Construction

CARBON CONCIOUS DESIGN



Carbon-conscious design means looking beyond how a building performs in operation.
It considers the **full carbon impact of a project**:

- How much energy the building needs
- What materials are being used/specified
- How those materials are sourced, manufactured, transported, maintained, and replaced
- How long the building and its materials will last
- How the site can support shade, wind protection, biodiversity, and climate resilience
- **Whether the project can REDUCE EMISSON and/or STORE CARBON**

Carbon-Conscious Design Strategy



#1 Build less

Design compact, efficient forms and avoid unnecessary floor area, complexity, and material use.



#2 Envelope first

Use a high-performance, well-insulated, airtight enclosure to reduce heating and cooling demand.



#3 Use less

Right-size systems, materials, and equipment. Reduce waste before adding more technology.



#4 Electrify

Replace fossil-fuel heating, hot water, cooking, and equipment with efficient electric alternatives.



#5 Power cleanly

Meet the remaining energy demand with clean electricity and renewable energy where possible.



#6 Choose better materials

Prioritize low-carbon, reused, recycled, durable, and bio-based materials that can store carbon.



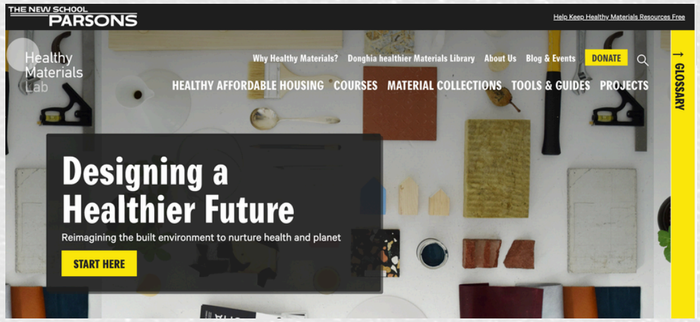
#7 Build once — and verify performance

Design for durability, adaptability, and resilience; commission systems early and monitor them over time.



RESOURCES TO LOOK

Healthy Materials Lab at Parsons School of Design

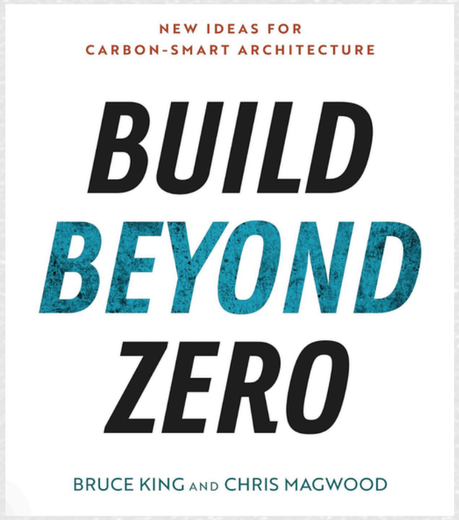


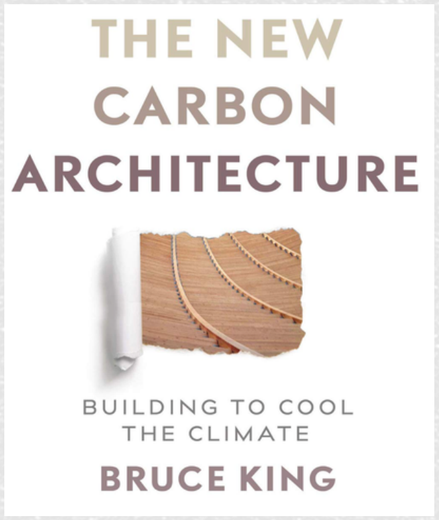
PASSIVE BUILDINGS CANADA

RMI

ONTARIO NATURAL BUILDING COALITION

BUILDERS FOR CLIMATE ACTION







PASSIVE HOUSE ACCELERATOR

The Passive House Network

UN environment programme

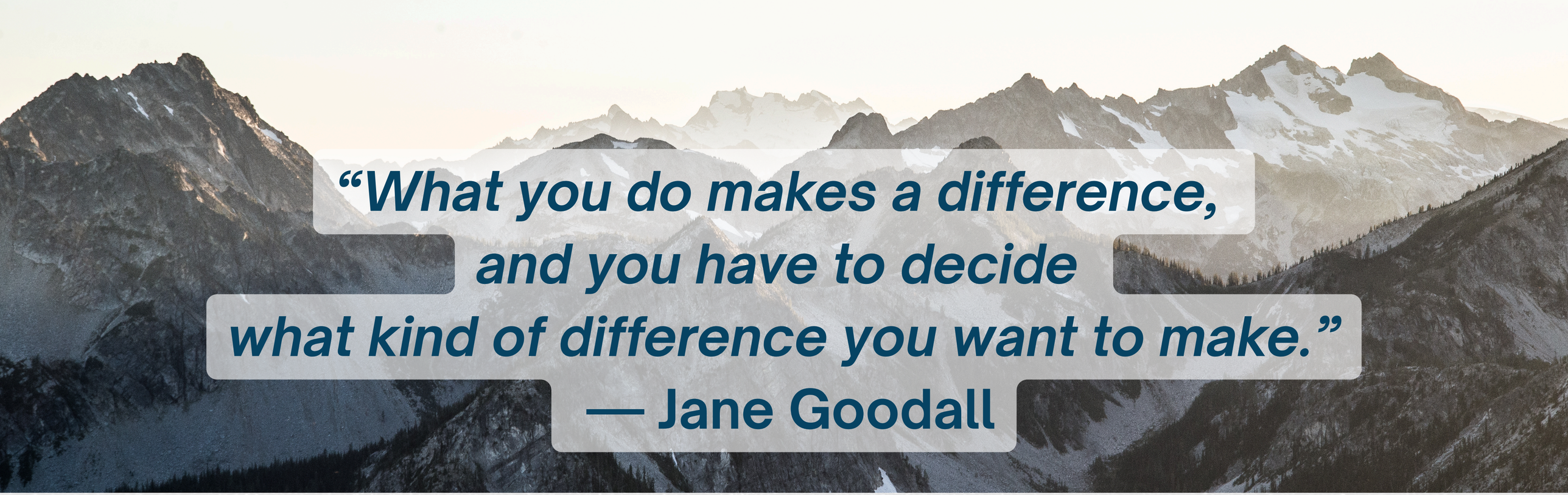
“Every project is a carbon decision”



For a Low-Carbon Future

1. Can we build less?
2. Can we retain and restore more?
3. Can we reduce energy demand first?
4. Can we choose materials with a better full-life story?
5. And can we ask for more transparency from the products and companies we specify?

“..and every project gives us choices”



Thank You

If you'd like to continue the conversation and/or Interested in presenting this session to your organization? Contact me.

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