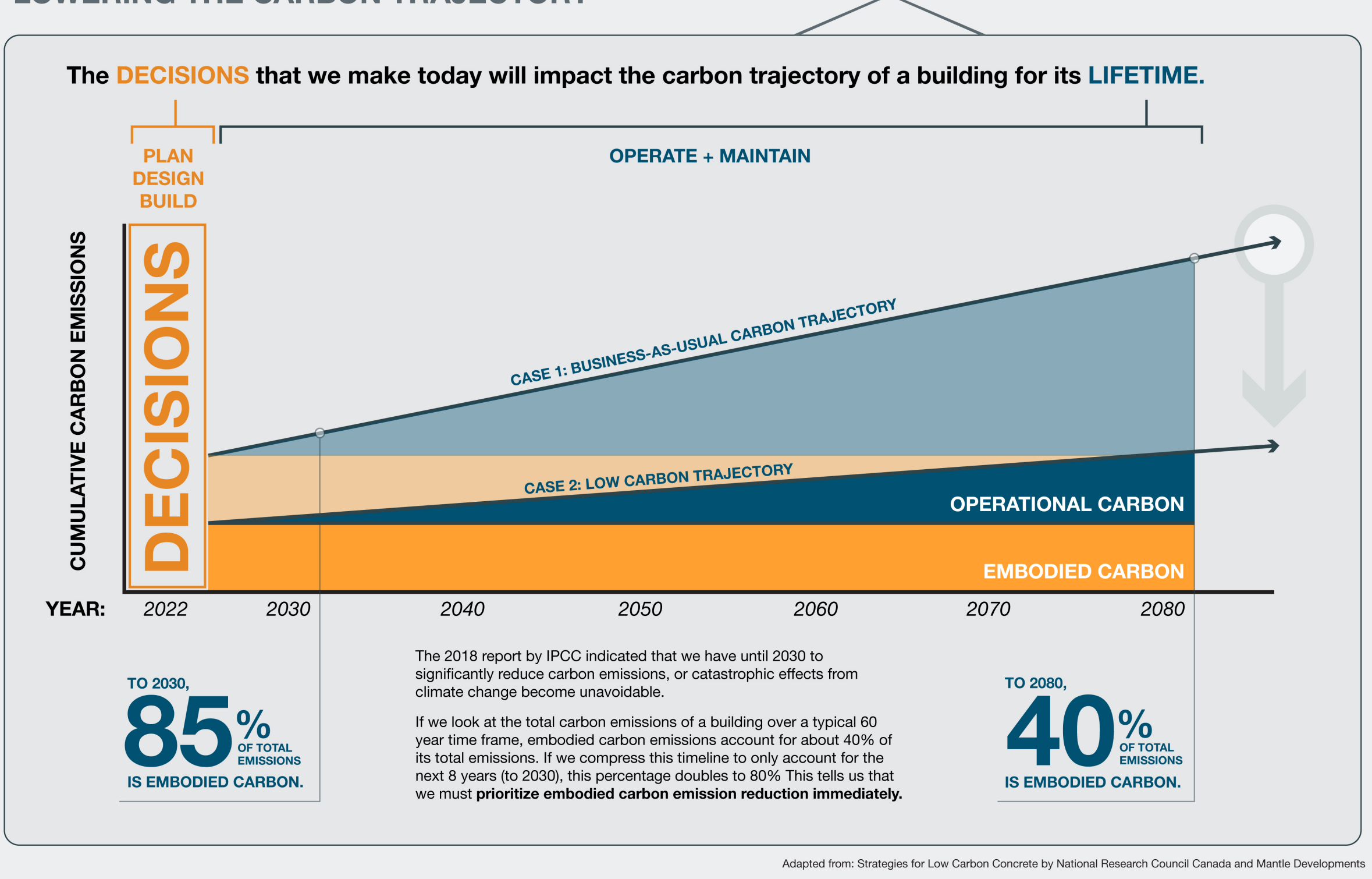
# LOW CARBON NOW
for Multi-Unit Residential Developments in Toronto

The Carbon Trajectory

THE TIME TO ACT IS NOW.
GREENHOUSE GAS EMISSIONS CUT TODAY ARE WORTH MORE THAN THE CUTS PROMISED IN THE FUTURE.

LOWERING THE CARBON TRAJECTORY

The DECISIONS that we make today will impact the carbon trajectory of a building for its LIFETIME.



TO 2030, **85%** OF TOTAL EMISSIONS IS EMBODIED CARBON.

The 2018 report by IPCC indicated that we have until 2030 to significantly reduce carbon emissions, or catastrophic effects from climate change become unavoidable.

If we look at the total carbon emissions of a building over a typical 60 year time frame, embodied carbon emissions account for about 40% of its total emissions. If we compress this timeline to only account for the next 8 years (to 2030), this percentage doubles to 80% This tells us that we must **prioritize embodied carbon emission reduction immediately.**

TO 2080, **40%** OF TOTAL EMISSIONS IS EMBODIED CARBON.

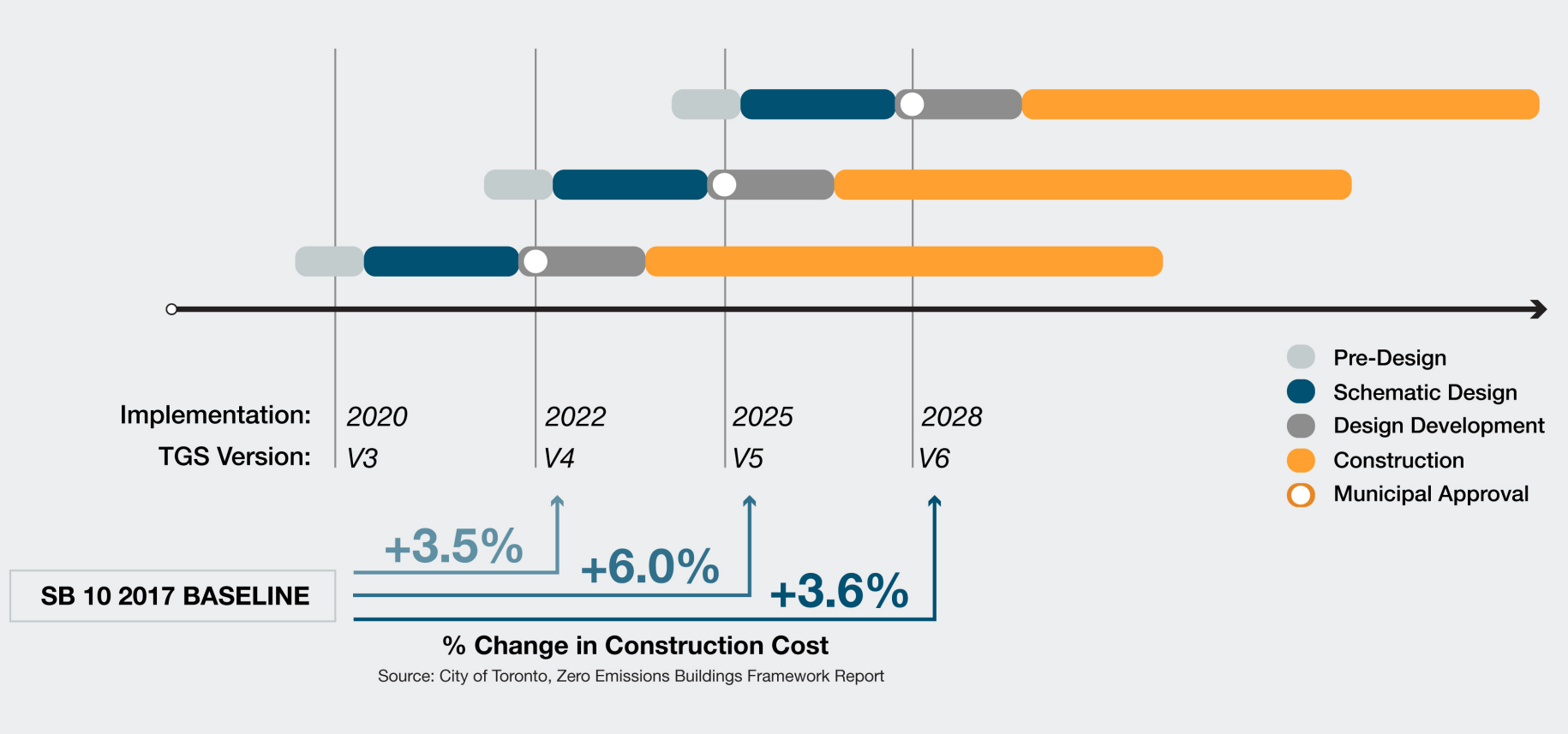
Adapted from: Strategies for Low Carbon Concrete by National Research Council Canada and Mantle Developments

URGENCY IN TORONTO

As part of Toronto's *Net Zero by 2040* initiative, projects in the City of Toronto applying for **SPA in 2028** will need to be designed to meet **net zero operational carbon,** Toronto Green Standard (TGS) v6.

A costing study as part of the Zero Emissions Building Framework by the City of Toronto found marginal cost differences between meeting TGS v4 requirements and v6. This is largely due to smaller mechanical systems subsidizing the cost of high performance envelopes.

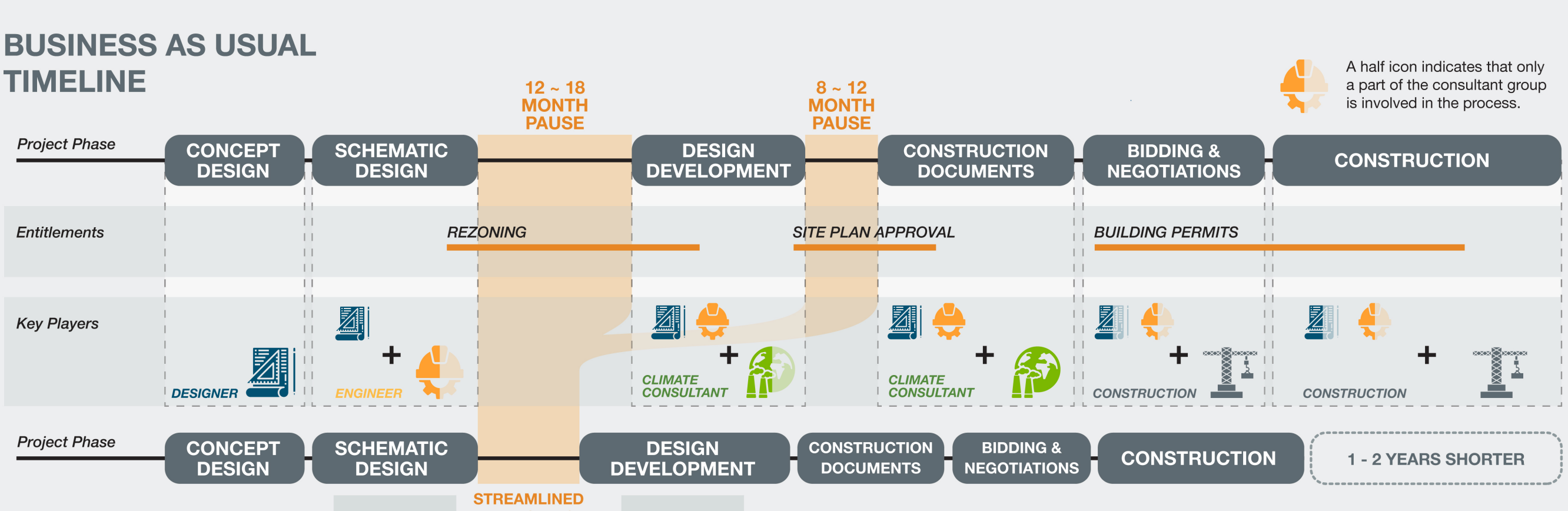
Now in 2022, many projects in an early design phase will have to meet TGS v5 requirements, which is significantly more costly than fully committing to v6. Projects should explore what it takes to go all the way to net zero now.



% Change in Construction Cost
Source: City of Toronto, Zero Emissions Buildings Framework Report

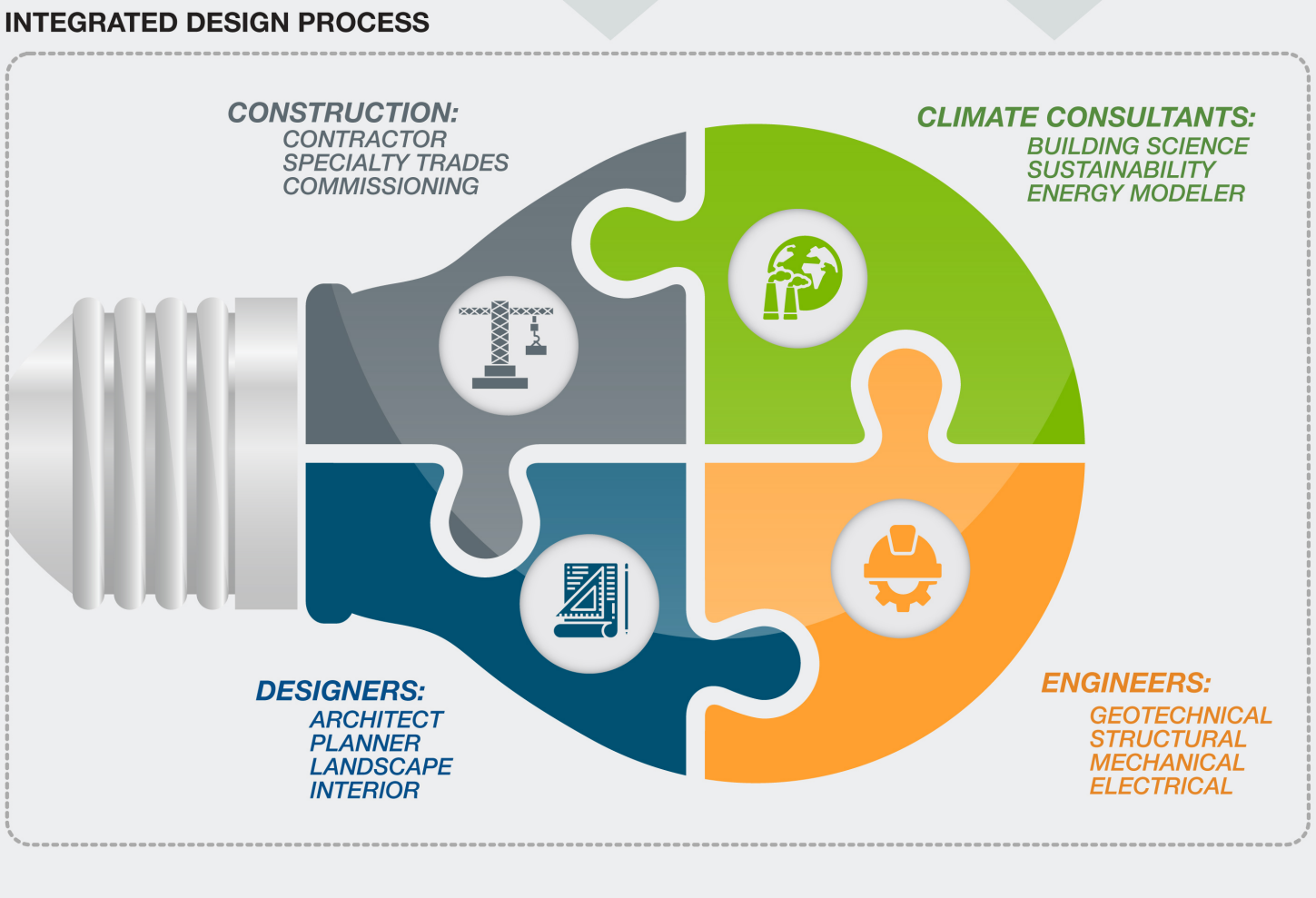
Project Timeline

BUSINESS AS USUAL TIMELINE


A half icon indicates that only a part of the consultant group is involved in the process.
12 ~ 18 MONTH PAUSE
8 ~ 12 MONTH PAUSE
Project Phase
CONCEPT DESIGN
SCHEMATIC DESIGN
DESIGN DEVELOPMENT
CONSTRUCTION DOCUMENTS
BIDDING & NEGOTIATIONS
CONSTRUCTION
Entitlements
REZONING
SITE PLAN APPROVAL
BUILDING PERMITS
Key Players
DESIGNER
ENGINEER
CLIMATE CONSULTANT
CONSTRUCTION
Project Phase
CONCEPT DESIGN
SCHEMATIC DESIGN
STREAMLINED APPROVALS PROCESS
DESIGN DEVELOPMENT
CONSTRUCTION DOCUMENTS
BIDDING & NEGOTIATIONS
CONSTRUCTION
1 - 2 YEARS SHORTER

STREAMLINED TIMELINE

INTEGRATED DESIGN PROCESS


CONSTRUCTION:
CONTRACTOR
SPECIALTY TRADES
COMMISSIONING
CLIMATE CONSULTANTS:
BUILDING SCIENCE
SUSTAINABILITY
ENERGY MODELER
DESIGNERS:
ARCHITECT
PLANNER
LANDSCAPE
INTERIOR
ENGINEERS:
GEOTECHNICAL
STRUCTURAL
MECHANICAL
ELECTRICAL

Our current timeline of going from design to construction in Toronto is incredibly slow, and especially so if we compare our process to other major cities across the world. This is largely due to two main approvals processes that the majority of projects are subjected to by the City of Toronto.

The Rezoning Application and Site Plan Approval put the project on pause for an average of two years or longer. In this time, developers are accumulating borrowing costs, which is capital that could have been invested into a higher quality building.

1. REZONING APPLICATION
Submitted at end of SD
12 - 18 month pause

2. SITE PLAN APPROVAL
Submitted at end of DD
8 - 12 month pause

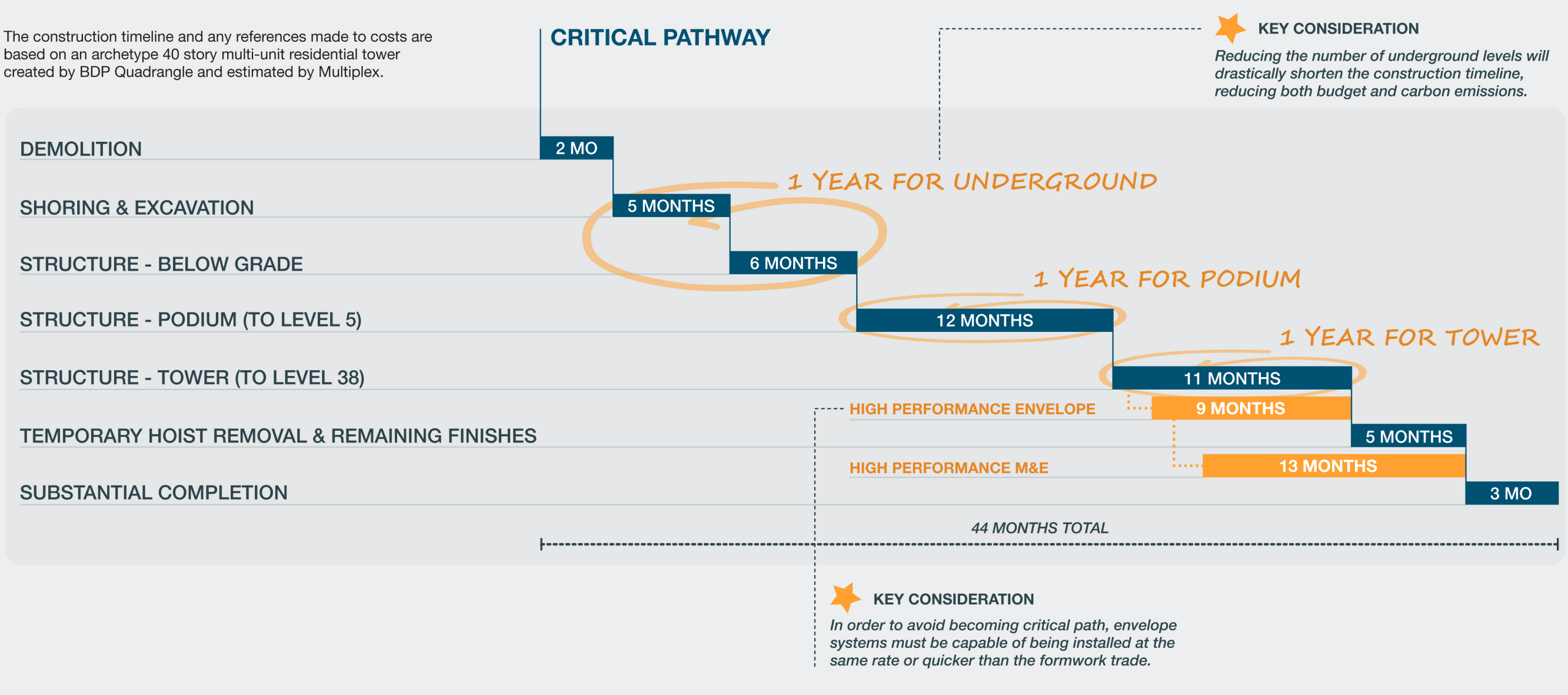
STREAMLINED PROCESS
Submitted at end of SD
8 - 12 month pause

Additionally, the approvals process divides our projects into shorter, non-concentrated phases, where only the most essential consultants are brought onboard in early phases: it is these early phases where the most crucial decisions are made that impact the carbon trajectory of the building.

By streamlining the two approvals processes, combining them into one application to be submitted at the end of Schematic Design, projects are able to bring key consultants at the onset of a project, creating an integrated design process that uses "joined-up thinking" to make the right decisions at the right time.

CONSTRUCTION TIMELINE

The construction timeline and any references made to costs are based on an archetype 40 story multi-unit residential tower created by BDP Quadrangle and estimated by Multiplex.



KEY CONSIDERATION
Reducing the number of underground levels will drastically shorten the construction timeline, reducing both budget and carbon emissions.

KEY CONSIDERATION
In order to avoid becoming critical path, envelope systems must be capable of being installed at the same rate or quicker than the formwork trade.

THINKTANK FOR CHANGE NOW

The next 8 years are critical to lowering our carbon trajectory. Though we are making some progress, regulatory change is not happening quickly enough to have the impact that is required. Of the 323 cranes in the air in Toronto, 90% serve the residential construction market. Unfortunately, residential construction has been the slowest to adopt low carbon design principles. That's going to need to change. We reached out to a few Toronto stakeholders to discuss why the change was happening so slowly and identified three major levers that should be prioritized immediately.

Smith + Andersen

What can we do now?

1 BUILD SMARTER STRUCTURES.

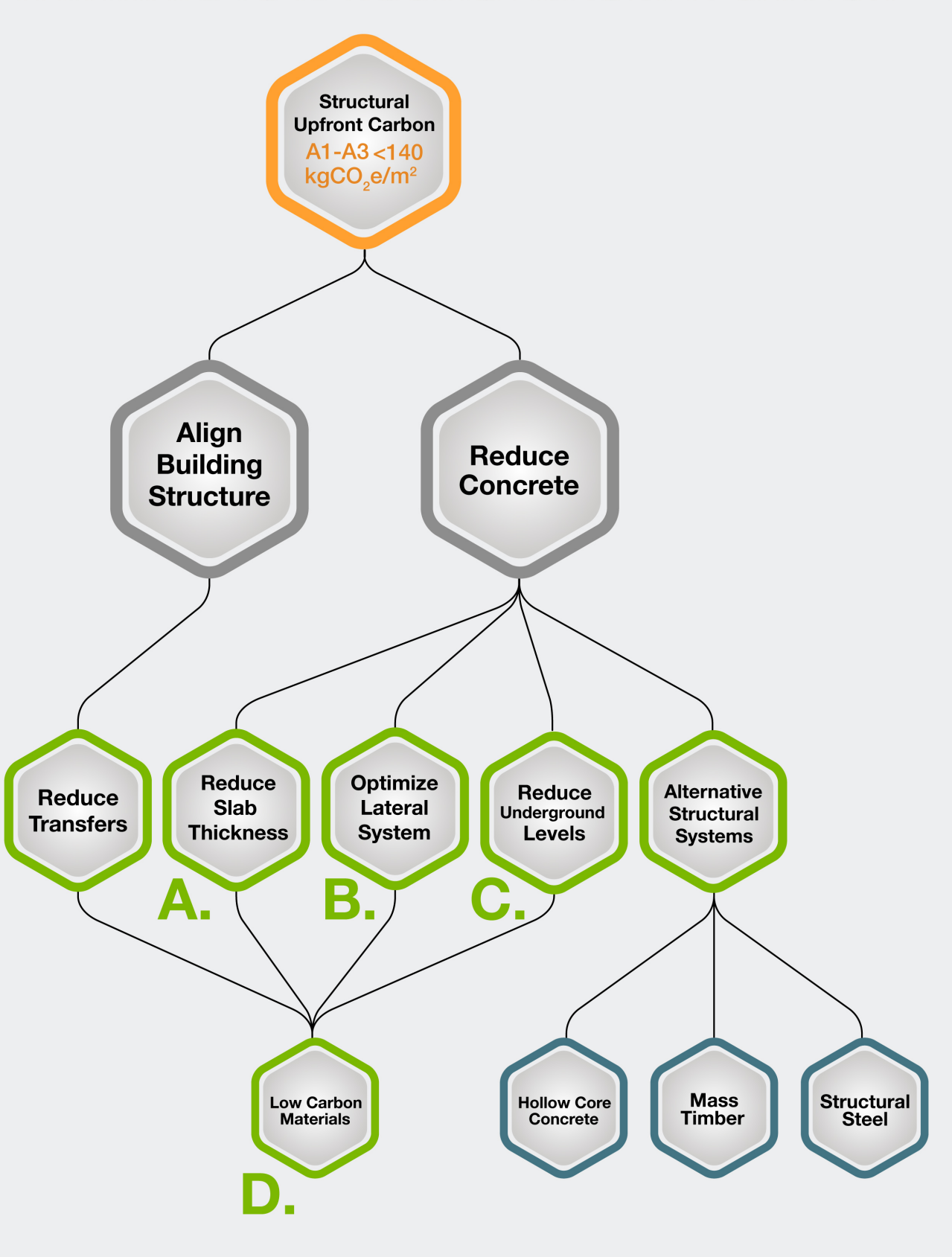
A building's structure accounts for about **50%** of its embodied carbon.

According to a study by Half Studio at University of Toronto, **concrete** contributed **31-59%** of a building's total embodied carbon for mid and high-rise residential projects.

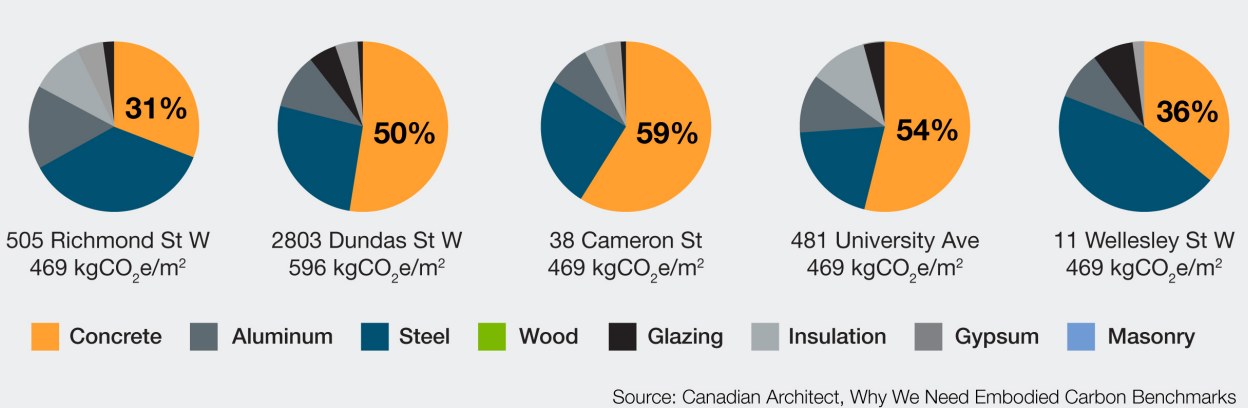
Set by The Institution of Structural Engineers (IStructE), structural systems should be targeting **140 kgCO$_2$e/m²** by 2030*. Meeting this rigorous target starts by aligning the structure, reducing quantity of concrete, and building with low carbon materials.

*Source: iStructE, Setting carbon targets: an introduction to the proposed SCORS rating scheme

PATHWAYS TO REDUCING EMBODIED CARBON


Structural Upfront Carbon
A1-A3 <140 kgCO2e/m²
Align Building Structure
Reduce Concrete
Reduce Transfers
Reduce Slab Thickness
Optimize Lateral System
Reduce Underground Levels
Alternative Structural Systems
A.
B.
C.
Low Carbon Materials
D.
Hollow Core Concrete
Mass Timber
Structural Steel

EMBODIED CARBON BY MATERIAL TYPE

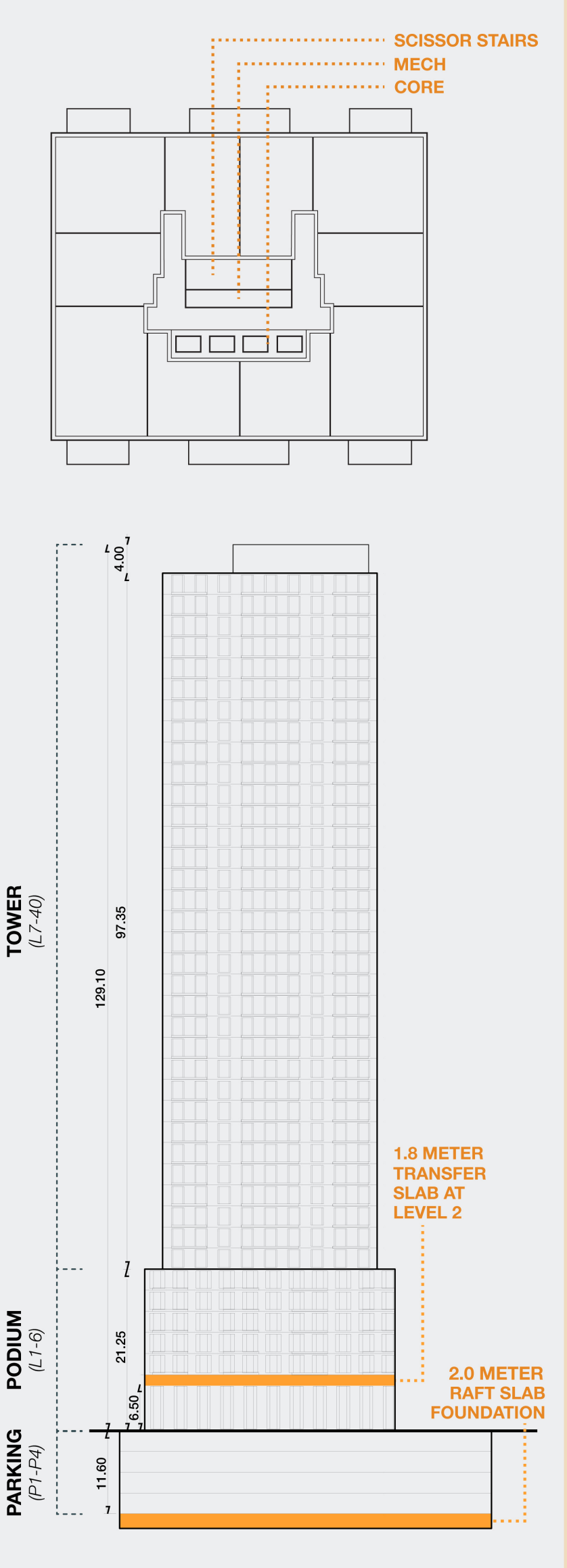


Source: Canadian Architect, Why We Need Embodied Carbon Benchmarks and Targets in Building Standards and Policies: An Open Letter

We calculated the embodied carbon of an archetype 40 storey multi-unit residential tower built in the GTA. The baseline structural system assumes a reinforced concrete structure with four levels of underground parking, a tanked foundation system and raft slab, 200mm typical floor slabs, one major transfer slab and shear walls between suites and a central core for lateral stability.

ARCHETYPE TOWER

40 FLOORS w/ 6 storey podium
10 UNITS per floor
750 SQUARE METER floor plates
4 ELEVATOR CORE w/ scissor stairs
4 LEVELS OF underground parking


SCISSOR STAIRS
MECH
CORE
TOWER (L7-40)
PODIUM (L1-6)
PARKING (P1-P4)
4.00
97.35
129.10
21.25
6.50
11.60
1.8 METER TRANSFER SLAB AT LEVEL 2
2.0 METER RAFT SLAB FOUNDATION

ADDITIONAL REDUCTIONS
1. All balconies were removed.
2. The transfer at level 2 uses only transfer bands and a transfer slab for the scissor stairs.

Structural Embodied Carbon of Archetype: **421** kgCO$_2$e/m²

304 kgCO$_2$e/m²

FINAL VALUE **200** kgCO$_2$e/m²

CONCLUSIONS

Based on our study results, following standard Ontario construction practices or the "Practical Pathway", we demonstrated a **52%** embodied carbon reduction in the structural system.

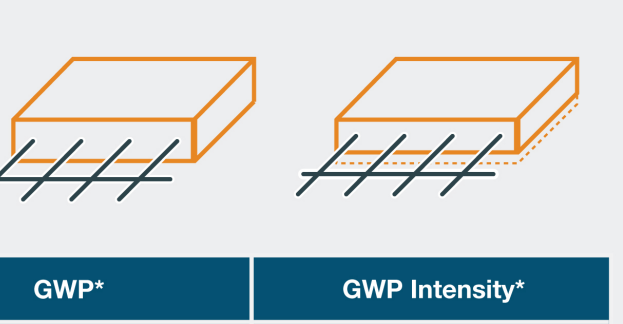
To meet the target of **140 kgCO$_2$e/m²** our construction industry needs to innovate as a whole. Let's rethink our most fundamental assumptions about structure and concrete:

- Optimize construction methods and market-readiness for low-carbon materials in relation to cost and schedule impacts through early contractor involvement
- Consider alternative slab systems
- Minimize below-grade levels
- Reduce the quantity of vertical elements
- Minimize the number of transfers through early structural engineer involvement in development of the architectural program
- Ensure that optimizing the structure does not result in additional embodied carbon elsewhere (i.e. acoustic materials).

REDUCE CONCRETE

A. Slab Thickness

Floor slabs are the single largest contributor, accounting for 48% of the building's embodied carbon with a transfer slab, and 38% without. We explored various ways to thin the slabs using means and methods that are not native to the Toronto trades to understand the potential impacts.

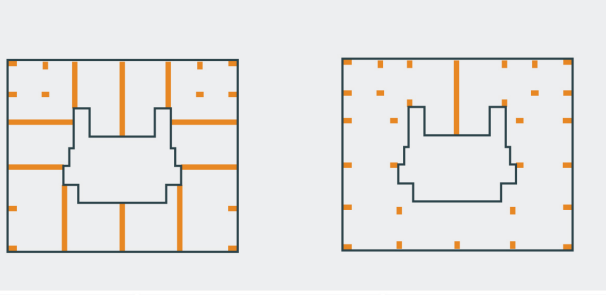


Slab System	GWP* (tonnes CO$_2$e)	GWP Intensity* (kg CO$_2$ e/m²)
1. Baseline - 200mm Reinforced Concrete Slab *Typical slab system in Toronto requiring no acoustic buildup.*	4,968	221
2. Achievable - 180mm Reinforced Concrete Slab** *Reduction in slab thickness was achieved on the same grid layout with a reshoring procedure practiced in Western Canada. We need trades onboard very early to be able to achieve this.*	4,740	210 (-5%)
3. Design Limit - 165mm Post-Tensioned Slab*** *Post-tensioned slabs are typically used in Europe to get longer spans for the same slab depth. Acoustic issues could arise due to its thickness.*	4,479	199 (-10%)

* GWP results reflect the residential tower only (level 7 & up).
** Acoustic elements for a 180mm slab would add about 5.1 kgCO$_2$e/m².
*** Acoustic elements for a 165mm slab would add about 9.5 kgCO$_2$e/m².

B. Lateral System

The second largest contributor are the shear walls used as the common lateral strategy in Toronto tower design. As shear walls also serve the function of fire and acoustic separation between suites, architectural demising walls were accounted for in the calculations where shear walls were removed.

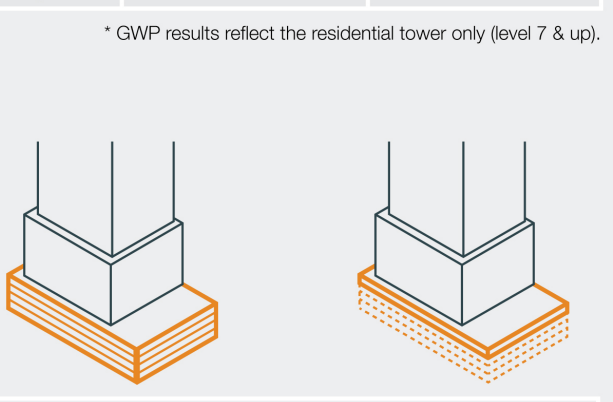


Lateral System	GWP* Structure (tonnes CO$_2$e)	GWP Intensity* Structure (kg CO$_2$ e/m²)	GWP Intensity Demising Walls (kg CO$_2$ e/m²)	GWP Intensity Demising Walls & Structure (kg CO$_2$ e/m²)
1. Shear Walls between suites	5,439	241	-	241
2. Wallumns	5,281	234 (-2.9%)	+2.0	237 (-2.1%)
3. Discrete Columns	5,014	223 (-7.8%)	+3.9	227 (-6.2%)

* GWP results reflect the residential tower only (level 7 & up).

C. Underground Levels

Toronto's new foundation drainage provisions state that all foundations that are below the max groundwater table are required to be tanked. We assume the groundwater table is between P1 and P2, and that structural tanking is not required for option 4 and 5 (1 level of parking and no parking, respectively).



Underground Parking System	GWP GWP (tonnes CO$_2$e)	GWP Intensity (kg CO$_2$ e/m²)	% Difference from Option 1	% of Below-Grade Structure Contribution
1. 4 Levels Below-Grade	11,477	409	-	28%
2. 3 Levels Below-Grade	11,010	392	-4%	25%
3. 2 Levels Below-Grade	10,611	378	-8%	22%
4. 1 Level Below-Grade	9,288	331	-12%	11%
5. No Below-Grade Parking	9,246	329	-13%	10%

LOW CARBON MATERIALS

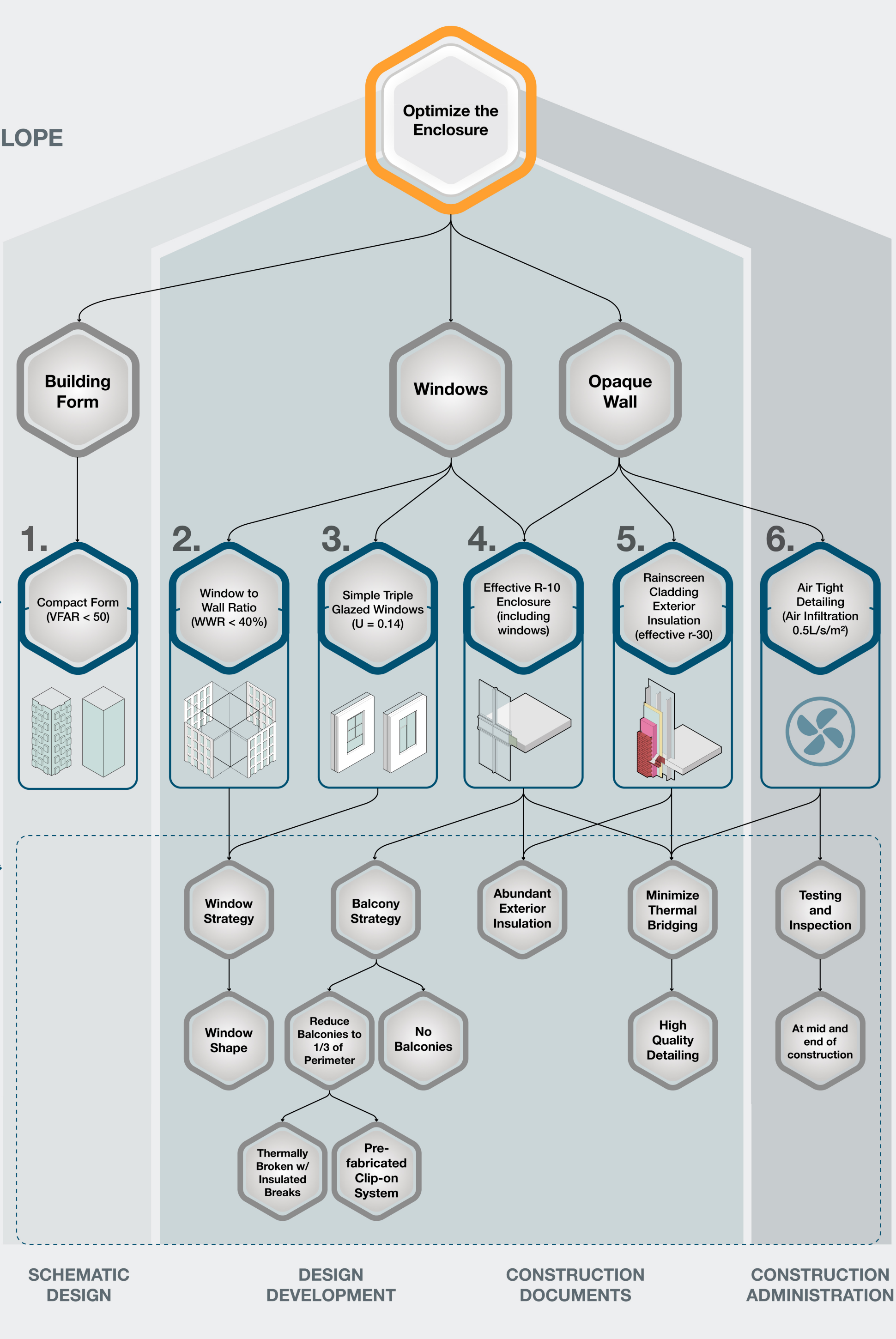
D. Low Carbon Reinforced Concrete

Case	Description	GWP Intensity (kg CO$_2$ e/m²)	Difference from Baseline
Practical Pathway (baseline)	Industry average concrete mixes consisting of General Use Portland Cement (GU) and 10% SCM content Industry average reinforcing bars.	304	-
Strategy 1	Concrete mixes with GU cement and 35%-50% slag cement	262	-14%
Strategy 2	Concrete mixes with General Use Portland Limestone (GUL) cement and 35%-50% slag cement	249	-18%
Strategy 3	Lafarge's ECOPact Entry Level low-carbon concrete	240	-21%
Strategy 4	Lafarge's ECOPact Prime low-carbon concrete	209	-31%
Strategy 5	Lower-carbon rebar in comparison to North American industry average: Gerdau's rebar produced at the Whitby, ON plant.	296	-3%
Strategy 6	Strategy 4 and 5	200	-34%

Read the full report by Entuitive here.

2 PRIORITIZE THE ENCLOSURE.

PATHWAYS TO HIGH PERFORMANCE ENVELOPE


Optimize the Enclosure
Building Form
Windows
Opaque Wall
1. Compact Form (VFAR < 50)
2. Window to Wall Ratio (WWR < 40%)
3. Simple Triple Glazed Windows (U = 0.14)
4. Effective R-10 Enclosure (including windows)
5. Rainscreen Cladding Exterior Insulation (effective r-30)
6. Air Tight Detailing (Air Infiltration 0.5L/s/m²)
Window Strategy
Balcony Strategy
Abundant Exterior Insulation
Minimize Thermal Bridging
Testing and Inspection
Window Shape
Reduce Balconies to 1/3 of Perimeter
No Balconies
High Quality Detailing
At mid and end of construction
Thermally Broken w/ Insulated Breaks
Pre-fabricated Clip-on System
SCHEMATIC DESIGN
DESIGN DEVELOPMENT
CONSTRUCTION DOCUMENTS
CONSTRUCTION ADMINISTRATION

IMPORTANCE OF THE ENVELOPE

High-performance enclosures matter for the following reasons:

First and foremost, as the building's thermal energy demand is lowered, the operational carbon emissions decrease.

Second, it improves a building's resilience to climate change, meaning the building can maintain its environmental conditions in the event of a power outage.

Third, high performance enclosures minimize drafts and make even the spaces close to the perimeter comfortable for occupants, which increases the amount of useable area.

NON-NEGOTIABLE DECISIONS

To achieve rigorous metrics of TGS version 6, the following six decisions need to be met without compromise.

VARIABLE DECISIONS

The following decisions can be achieved in a number of ways.

TGS METRICS

ENERGY USE INTENSITY **(EUI):**
135 (v4) → 70 (v6)

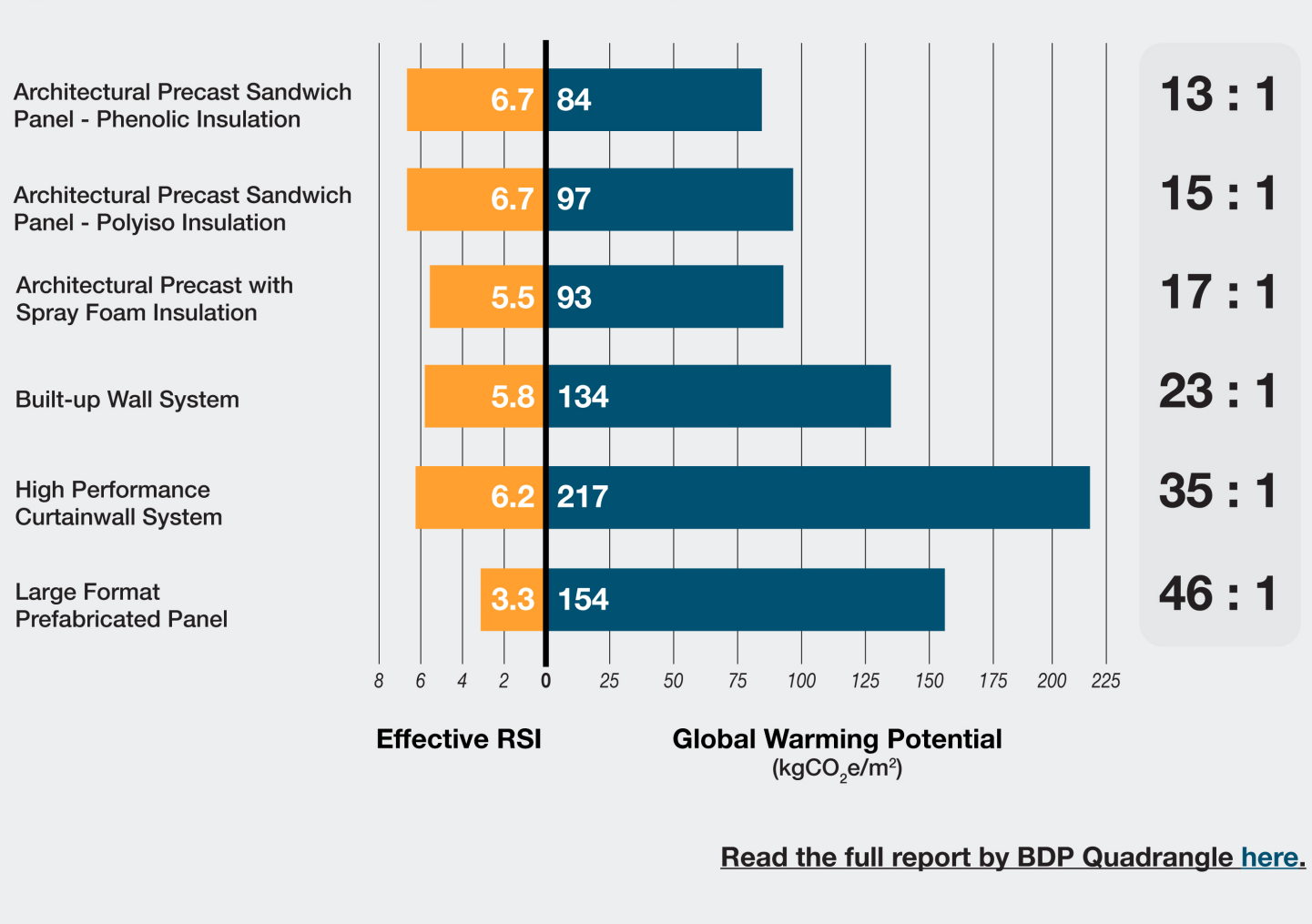
THERMAL ENERGY DEMAND INTENSITY **(TEDI):**
50 (v4) → 15 (v6)

GREENHOUSE GAS INTENSITY **(GHGI):**
15 (v4) → 5 (v6)

Current version 4 requirements will be updated to version 6 in 2028. Meeting these challenging targets will heavily rely on the performance of the envelope.

CARBON EFFICIENCY RATIO
(GWP: RSI-VALUE)

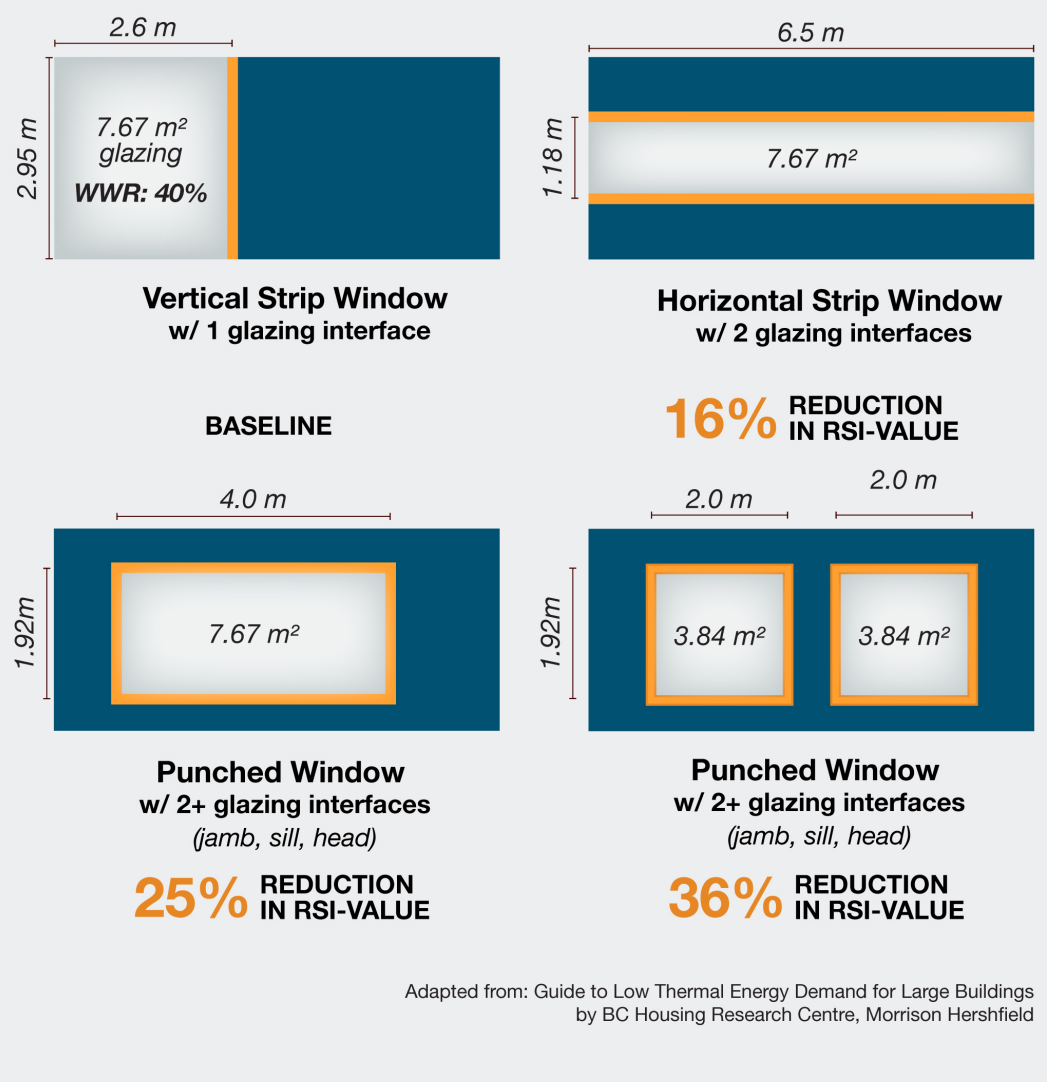
The enclosure of a multi-unit residential development accounts for roughly 30% of its embodied carbon. Any opportunity to reduce carbon emissions within the building envelope must consider both the impacts to the operational and embodied carbon. Using a ratio of thermal performance (RSI) and global warming potential (GWP) we can begin to evaluate the overall carbon intensity of each wall assembly. The lower the ratio, the lower the carbon impact.



Read the full report by BDP Quadrangle here.

WINDOW SHAPE
(EFFECT ON R-VALUE)

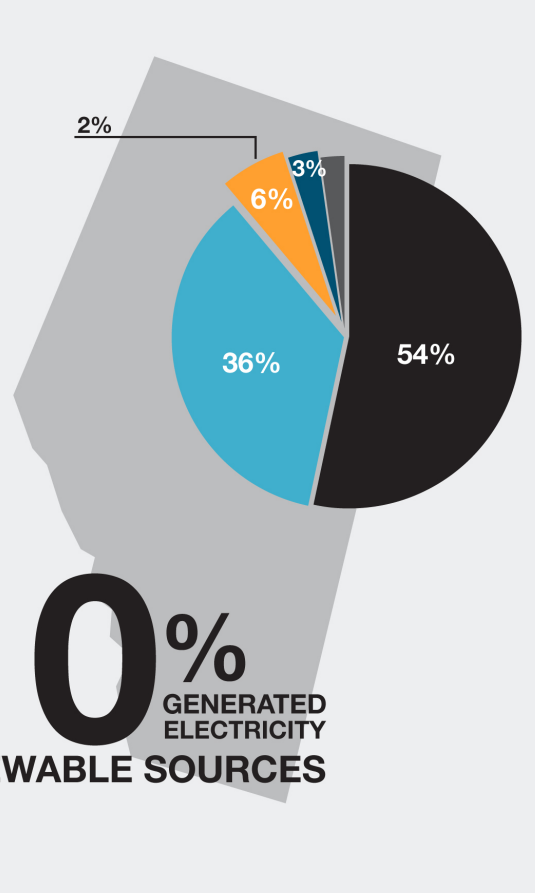
The following are four different window configurations for a typical residential bay size of 6.5 m x 2.95 m. As the total interface length of the glazing increases, the impact of thermal bridging can be as impactful as the thermal bridging at balconies due to the quantity of these details. By reducing the length, significant performance solutions can be realized.


2.6 m
2.95 m
7.67 m² glazing
WWR: 40%
Vertical Strip Window w/ 1 glazing interface
BASELINE
6.5 m
1.18 m
7.67 m²
Horizontal Strip Window w/ 2 glazing interfaces
16% REDUCTION IN RSI-VALUE
4.0 m
1.92m
7.67 m²
Punched Window w/ 2+ glazing interfaces (jamb, sill, head)
25% REDUCTION IN RSI-VALUE
2.0 m
2.0 m
1.92m
3.84 m²
3.84 m²
Punched Window w/ 2+ glazing interfaces (jamb, sill, head)
36% REDUCTION IN RSI-VALUE

Adapted from: Guide to Low Thermal Energy Demand for Large Buildings by BC Housing Research Centre, Morrison Hershfield

3 ELECTRIFY HEATING SYSTEMS.

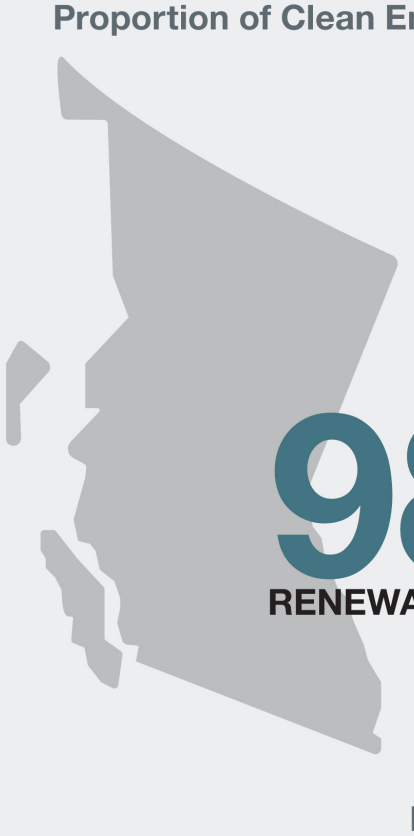
In Ontario, about 93% of electricity is produced through renewable resources. By electrifying the building's systems like heating, we can drastically reduce operational carbon emissions throughout its lifetime.



ALBERTA:
Proportion of Clean Energy

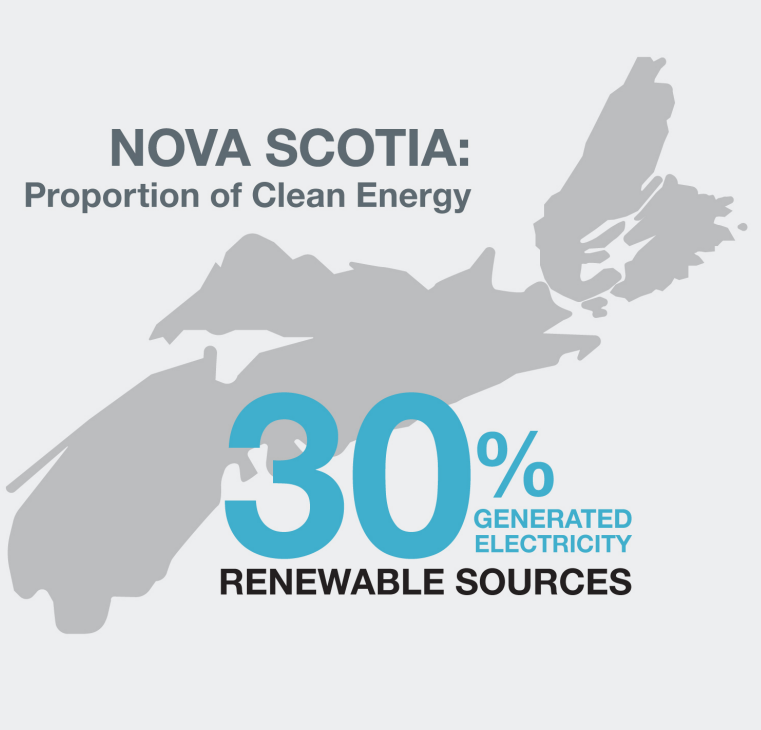
10% GENERATED ELECTRICITY RENEWABLE SOURCES

BRITISH COLUMBIA:
Proportion of Clean Energy

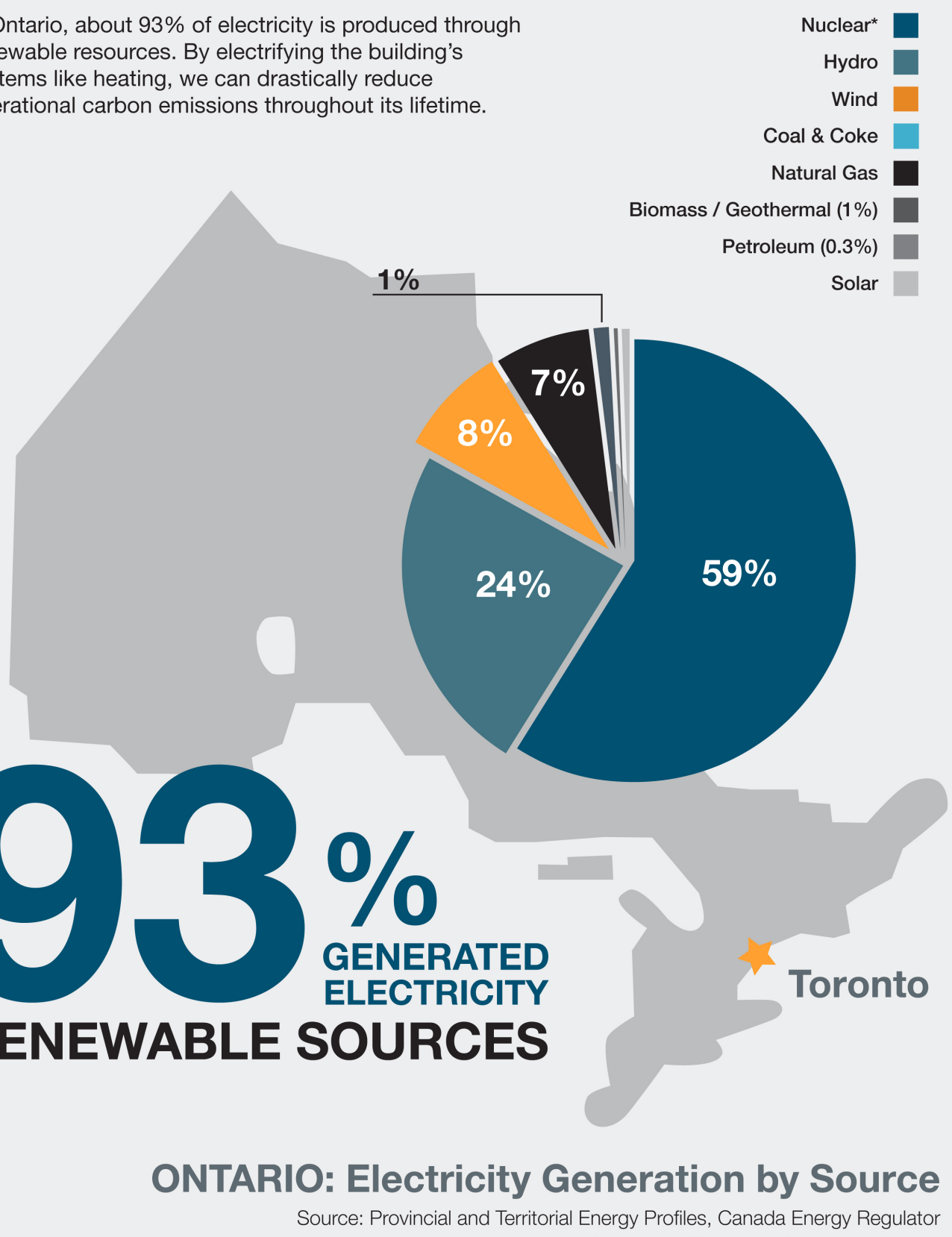


98% GENERATED ELECTRICITY RENEWABLE SOURCES

NOVA SCOTIA:
Proportion of Clean Energy



30% GENERATED ELECTRICITY RENEWABLE SOURCES



93% GENERATED ELECTRICITY RENEWABLE SOURCES

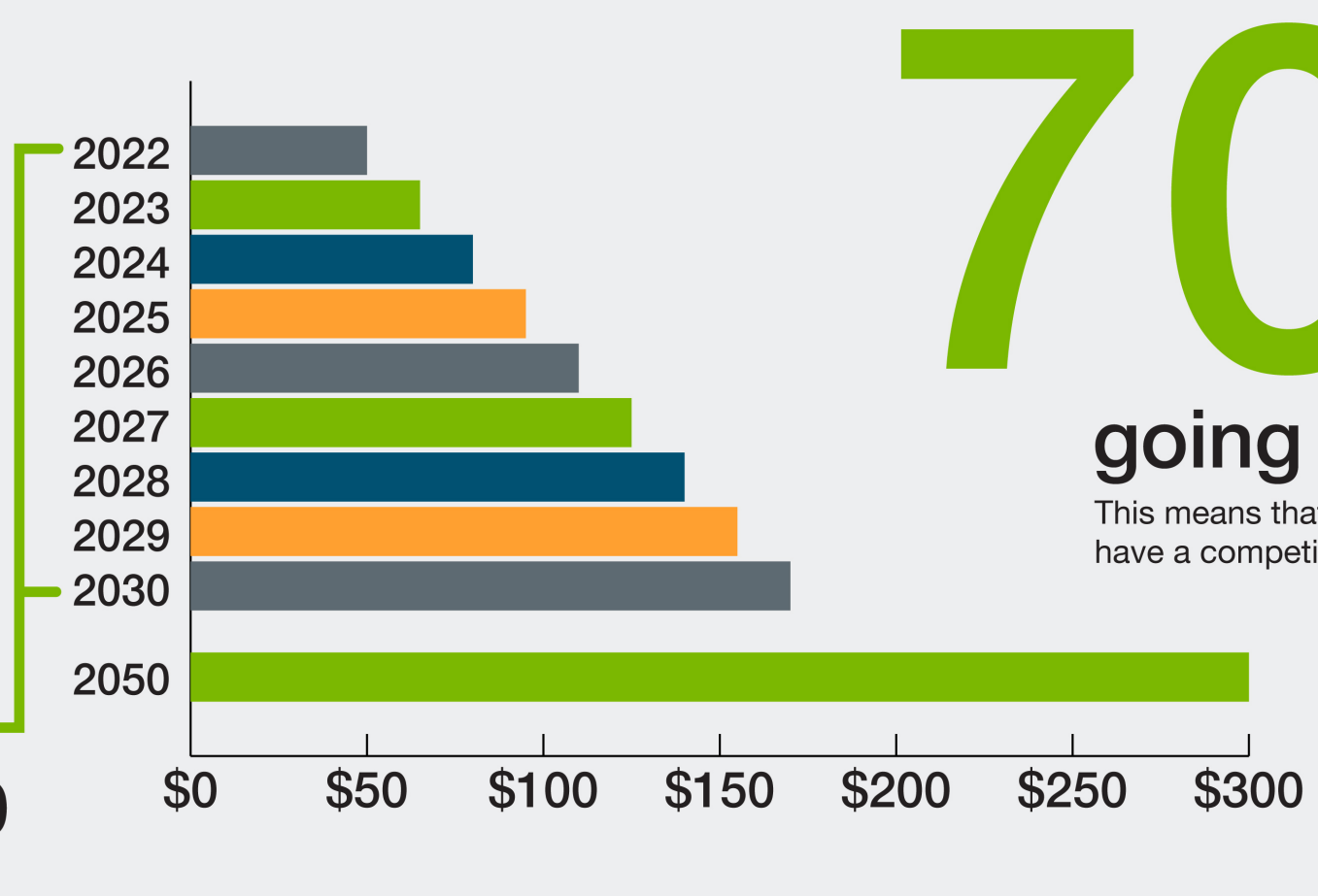
ONTARIO: Electricity Generation by Source
Source: Provincial and Territorial Energy Profiles, Canada Energy Regulator
* It is understood that there are differing views on whether nuclear energy should be included as a renewable resource.

CARBON TAX

Facilities that emit **50,000+ tonnes** of carbon annually are required to pay for their emissions. The cost per tonne of carbon will increase **340% by 2030.**

By electrifying the building, **70% of the savings** go to the tenants, and the remainder to the building owners.

COST PER TONNE
INCREASE OF
240% BY 2030



ELECTRIFYING THE BUILDING
WILL RESULT IN
70% of the savings going to tenants.

This means that fully electric buildings will have a competitive edge in the market.

A Call to Action

Developers,

Reduce underground parking.
So much embodied carbon lies underground.

Underground Parking accounts for:

+/-**25%** of construction time

+/-**13%** of structural embodied carbon

+/-**16%** of construction budget

Do we really need the parking?

Redistribute these resources to the building envelope

City Planners,

The rezoning process is costly for our planet.

Streamline the Approvals Process.

Shorten time between land purchase and construction.

Cut time, save money.

Free up capital for integrated design process.

Quality buildings FASTER

Architects,

Going from TGS v4 to TGS v5 costs **2.5%** more

Going from TGS v4 to TGS v6 costs **0.1%** more

Let's look at going all the way to NET ZERO, NOW.

We can pull integrated teams together earlier,
+
explore various pathways,
build consensus,
&
prepare for change on the horizon.

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