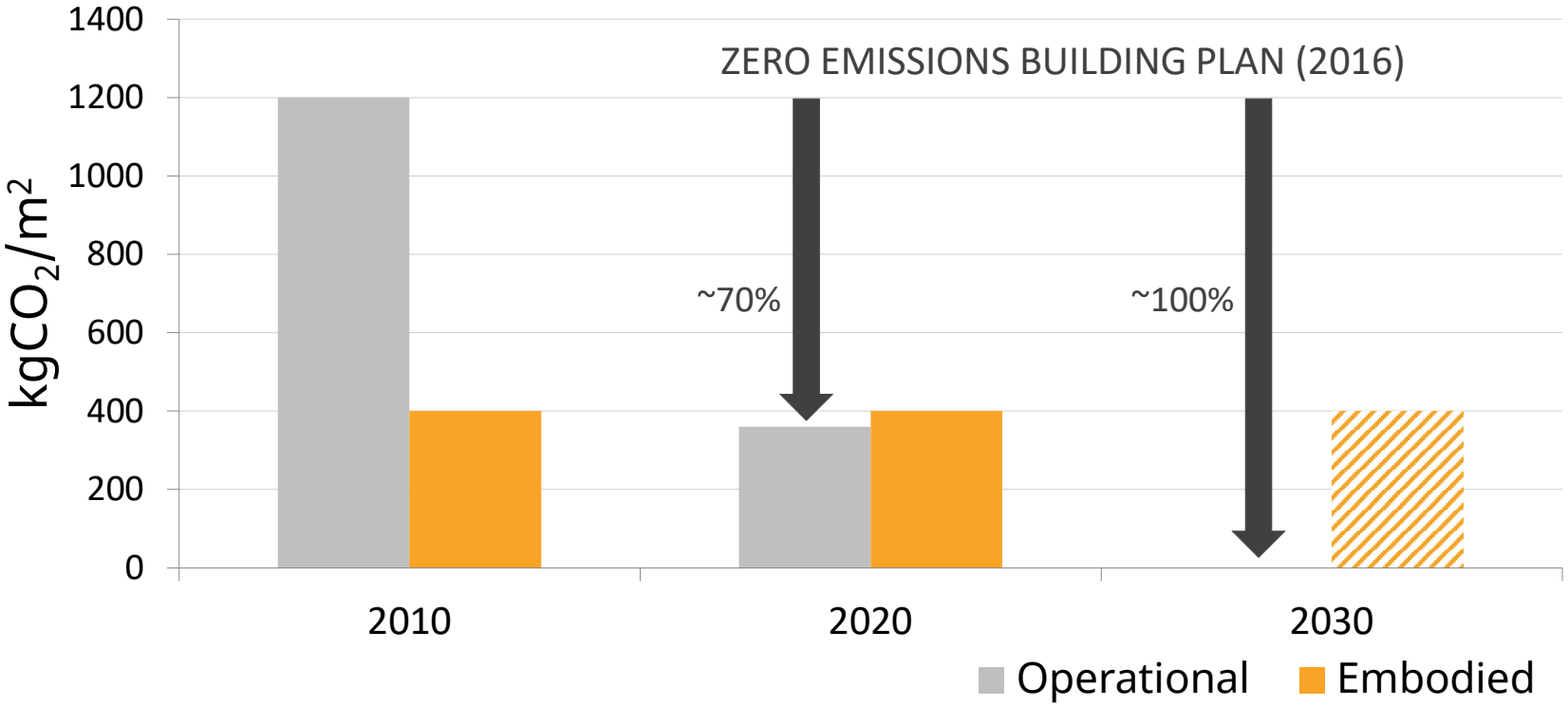
Embodied Carbon in Vancouver Building Bylaw 2025

May 6, 2024

CoV & CLF BC Workshop

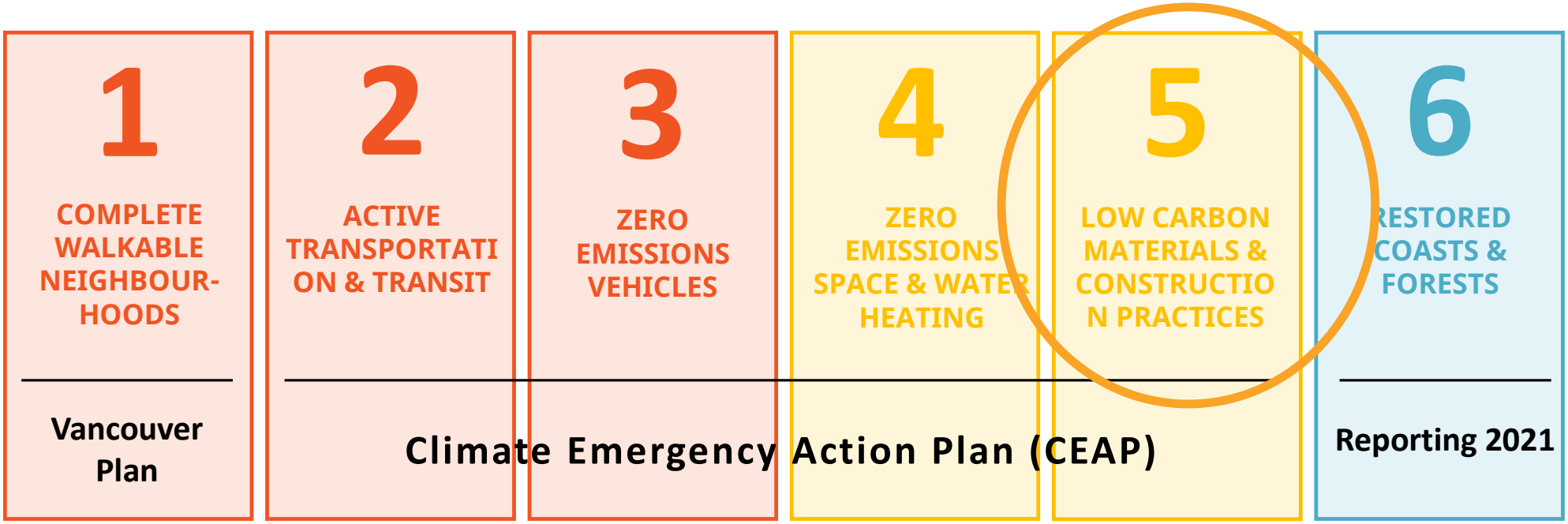
Whole Life Carbon Intensity of New Buildings in Vancouver



(Approximated over a 60yr life-cycle)

Climate Emergency Action Plan (2020)
Big Move 5

40% Embodied Carbon Reduction by 2030
(New Buildings)



Embodied Carbon in Vancouver Building Bylaw 2025

Embodied Carbon Strategy (2020)
Key Action Areas

Change the Rules

Policy and Regulation:

- Standardize baselines
- Require reductions in rezoning policies and/or codes
- Require reductions for City-owned buildings

Change the Market

Remove Barriers and Provide Incentives:

- Remove barriers in planning by-laws, policies, and guidelines
- Incentivize deep reductions

Change the Culture

Capacity Building and Industry Transformation:

- Coordinate, support, advocate, and share knowledge with other organizations and governments
- Support tools, training, and knowledge-sharing

Change the Context

Align with Complimentary Strategies and Actions

- Low carbon neighbourhoods
- Optimized parking requirements
- Zero emissions construction sites
- Zero waste & deconstruction
- Seismic resilience
- Green building economy

Including Code Changes
through Vancouver Building Bylaw (VBBL)

Code Changes* (Proposed in 2022)

Approved in 2022

2023

- wbLCA Reporting
- Equal or Less than 2x the Baseline (+100%)
    - Follow the Embodied Carbon Guidelines for Assessment & Setting Baseline

Approved in Principle in 2022

2025**

- wbLCA Reporting
- 20% Reduction: Up to 6-storeys, Can Be Built with Wood
- 10% Reduction: All Other Buildings
- 1 Responsible Materials Criteria

  (Sustainable and Ethical Materials; Healthy and Transparent Materials; Circular Materials)

  OR

  Double the Reduction (40% or 20%)

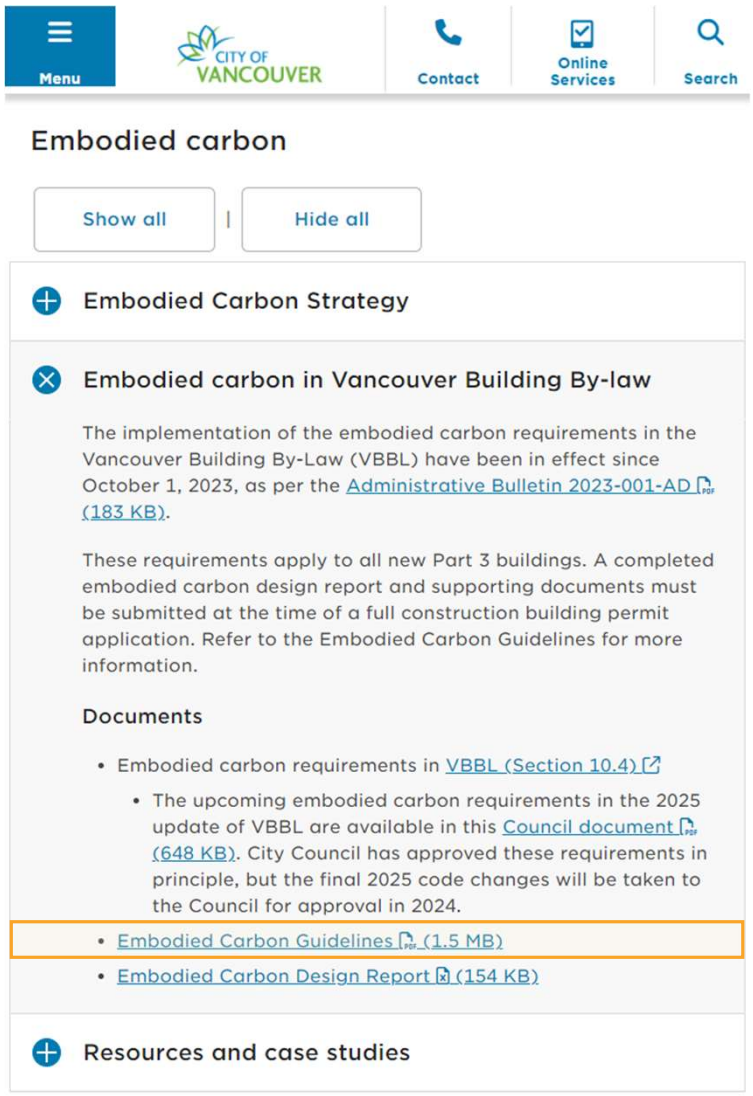
* Part 3 new buildings only (excludes 1-3 storeys residential)

** The City Council will approve the final 2025 code changes in 2024.

Implementation

Guidelines

- Compliance Pathways
- Standardized Embodied Carbon Modelling
  - wbLCA Scope
  - Materials & Emissions Quantification Methodology
  - Baseline Setting
  - Documentation & Submittal Requirements



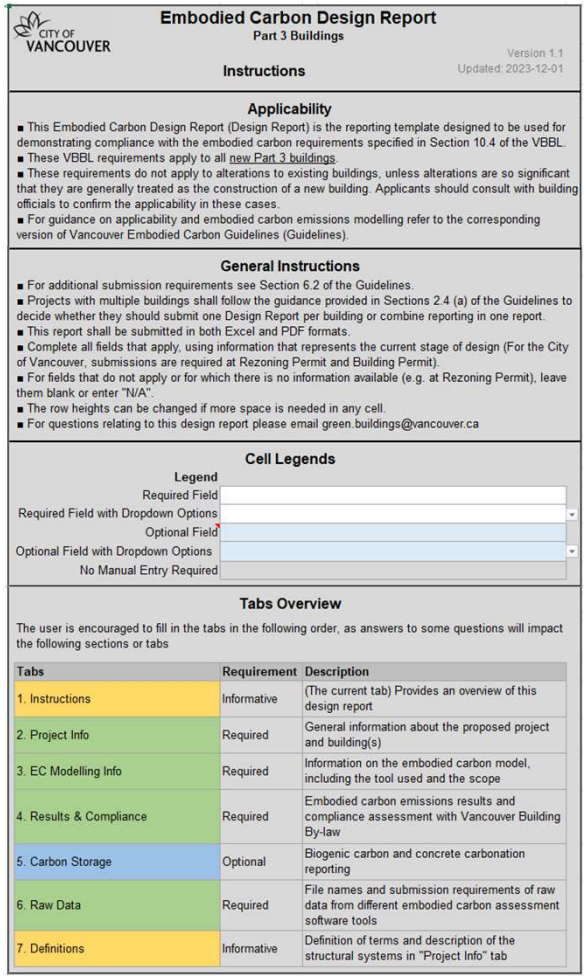
Embodied Carbon in Vancouver Building Bylaw 2025

https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx#embodied-carbon

Implementation

Design Report

- Standardized Reporting
- Standardized Data Collection
- Simplified Compliance Review Process



CITY OF VANCOUVER

Embodied Carbon Design Report
Part 3 Buildings

Version 1.1
Updated: 2023-12-01

Instructions

Applicability

- This Embodied Carbon Design Report (Design Report) is the reporting template designed to be used for demonstrating compliance with the embodied carbon requirements specified in Section 10.4 of the VBBL.
- These VBBL requirements apply to all new Part 3 buildings.
- These requirements do not apply to alterations to existing buildings, unless alterations are so significant that they are generally treated as the construction of a new building. Applicants should consult with building officials to confirm the applicability in these cases.
- For guidance on applicability and embodied carbon emissions modelling refer to the corresponding version of Vancouver Embodied Carbon Guidelines (Guidelines).

General Instructions

- For additional submission requirements see Section 6.2 of the Guidelines.
- Projects with multiple buildings shall follow the guidance provided in Sections 2.4 (a) of the Guidelines to decide whether they should submit one Design Report per building or combine reporting in one report.
- This report shall be submitted in both Excel and PDF formats.
- Complete all fields that apply, using information that represents the current stage of design (For the City of Vancouver, submissions are required at Rezoning Permit and Building Permit).
- For fields that do not apply or for which there is no information available (e.g. at Rezoning Permit), leave them blank or enter "N/A".
- The row heights can be changed if more space is needed in any cell.
- For questions relating to this design report please email green.buildings@vancouver.ca

Cell Legends

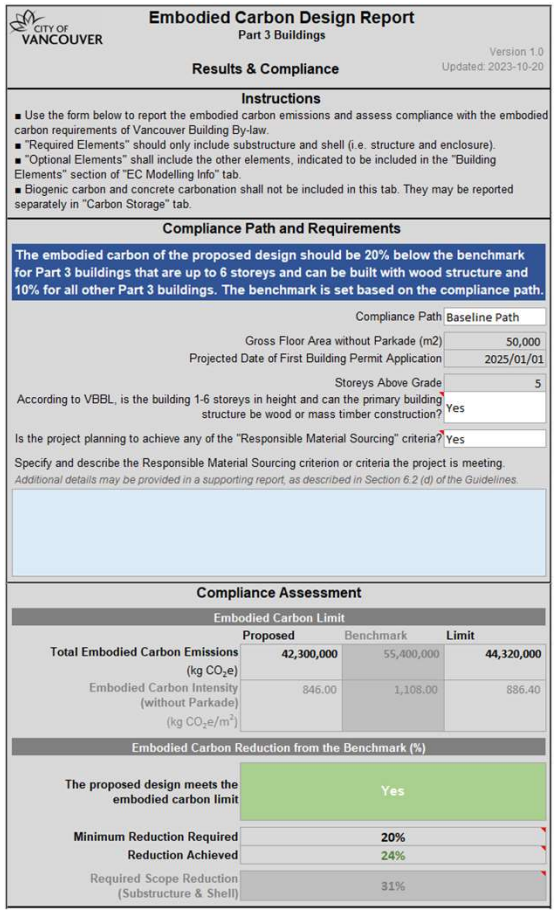
Legend	
Required Field	
Required Field with Dropdown Options	
Optional Field	
Optional Field with Dropdown Options	
No Manual Entry Required	

Tabs Overview

The user is encouraged to fill in the tabs in the following order, as answers to some questions will impact the following sections or tabs

Tabs	Requirement	Description
1. Instructions	Informative	(The current tab) Provides an overview of this design report
2. Project Info	Required	General information about the proposed project and building(s)
3. EC Modelling Info	Required	Information on the embodied carbon model, including the tool used and the scope
4. Results & Compliance	Required	Embodied carbon emissions results and compliance assessment with Vancouver Building By-law
5. Carbon Storage	Optional	Biogenic carbon and concrete carbonation reporting
6. Raw Data	Required	File names and submission requirements of raw data from different embodied carbon assessment software tools
7. Definitions	Informative	Definition of terms and description of the structural systems in "Project Info" tab

Instruction Tab



CITY OF VANCOUVER

Embodied Carbon Design Report
Part 3 Buildings

Version 1.0
Updated: 2023-10-20

Results & Compliance

Instructions

- Use the form below to report the embodied carbon emissions and assess compliance with the embodied carbon requirements of Vancouver Building By-law.
- "Required Elements" should only include substructure and shell (i.e. structure and enclosure).
- "Optional Elements" shall include the other elements, indicated to be included in the "Building Elements" section of "EC Modelling Info" tab.
- Biogenic carbon and concrete carbonation shall not be included in this tab. They may be reported separately in "Carbon Storage" tab.

Compliance Path and Requirements

The embodied carbon of the proposed design should be 20% below the benchmark for Part 3 buildings that are up to 6 storeys and can be built with wood structure and 10% for all other Part 3 buildings. The benchmark is set based on the compliance path.

Compliance Path	Baseline Path
Gross Floor Area without Parkade (m2)	50,000
Projected Date of First Building Permit Application	2025/01/01
Storeys Above Grade	5
According to VBBL, is the building 1-6 storeys in height and can the primary building structure be wood or mass timber construction?	Yes
Is the project planning to achieve any of the "Responsible Material Sourcing" criteria?	Yes

Specify and describe the Responsible Material Sourcing criterion or criteria the project is meeting.
Additional details may be provided in a supporting report, as described in Section 6.2 (d) of the Guidelines.

Compliance Assessment

Embodied Carbon Limit	Proposed	Benchmark	Limit
Total Embodied Carbon Emissions ($kg CO_2e$)	42,300,000	55,400,000	44,320,000
Embodied Carbon Intensity (without Parkade) ($kg CO_2e/m^2$)	846.00	1,108.00	886.40

Embodied Carbon Reduction from the Benchmark (%)	
The proposed design meets the embodied carbon limit	Yes
Minimum Reduction Required	20%
Reduction Achieved	24%
Required Scope Reduction (Substructure & Shell)	31%

Results & Compliance Tab

https://vancouver.ca/files/cov/embodied-carbon-design-report.xlsx

Implementation

Raw Data Collection

- Consistent Data Format
- Reduce Workload on Applicants to post-process
- Future High-quality Benchmarking

▸ **One Click LCA**

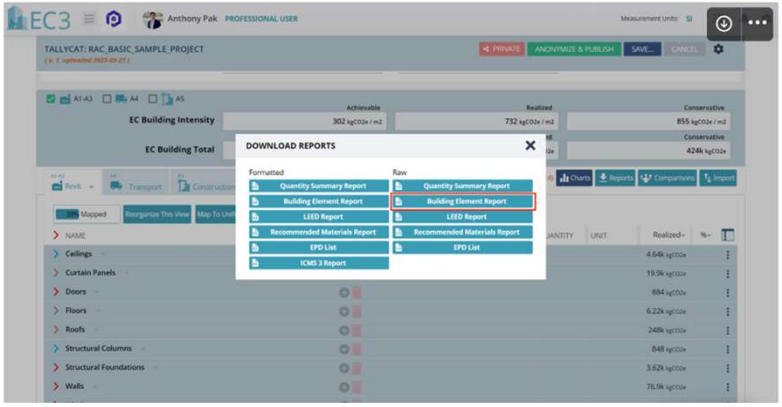
▸ **Athena**

▸ **Tally (tallyLCA)**

▾ **EC3 or tallyCAT**

Instructions

- **Results Export Sheets**
  - **Required: Building Elements Report (Raw)**
    - Select `Reports` and under the **Raw** column, click on `Building Element Report` spreadsheet.



  - **Optional: Building Elements Report (Formatted)**
    - Select `Reports` and under the **Formatted** column, click on `Building Element Report` spreadsheet.

https://vancouver.ca/files/cov/embodied-carbon-design-report.xlsx

Proposed Changes
Adjustments to the 2025 Code Changes Proposed in 2022

2023
(In Effect since October 2023)

- Applicability
  - All Part 3 new buildings
- Compliance
  - Report embodied carbon (wbLCA)

  AND
  - Limit: 2x the baseline (+100%)

2025
(Approved in Principle in 2022)

- Applicability
  - All Part 3 new buildings
- Compliance
  - Report embodied carbon (wbLCA)

  AND
  - Limit (≤ 6-storeys & can be wood): 20% reduction
  - Limit (all other): 10% reduction

  AND
  - 1 Responsible Materials Criteria

    OR
  - Double the reduction (40% or 20%)

2025
(Revised Proposed Change)

- Applicability
  - Part 3 new buildings, except for projects ≤ 1,800 m^2
- Compliance
  - Report embodied carbon (wbLCA)

  AND
  - Limit (all buildings): 10% reduction

  Total 10% through a combination of:
  - 5-10% whole-building reduction
  - 0-5% Industry Leadership Credits

* The wbLCA, baseline, and compliance reporting should be in accordance with the Embodied Carbon Guidelines.

Revised Proposed Changes

- ## Applicability

  All Part 3 new buildings, exempt for small size projects ($\leq$ 1,800 m^2)

- ## Compliance Pathways

Report embodied carbon through conducting wbLCA

AND

1. Reduce whole-building embodied carbon by 10%

OR

2. As acceptable to the Chief Building Official

Revised Proposed Changes

- ## Applicability

  All Part 3 new buildings, exempt for small size projects ($\leq$ 1,800 m^2)

- ## Compliance Pathways

Report embodied carbon through conducting wbLCA

AND

1. Reduce whole-building embodied carbon by 10%

5-10% Whole-building Reduction (shown through wbLCA)	+	0-5% Reduction Credit (Industry Leadership Credits)

OR

2. As acceptable to the Chief Building Official

5-10% Whole-building Reduction

Achievable with No/Minimal Cost & Schedule Implications

- 5% is achievable no cost & 10% likely at no cost
  - Most common solutions: wood construction, low-carbon concrete & insulation, design efficiency
  - Other solutions: mass timber construction, reuse
- AND we allow 0-5% Industry Leadership Credits
- AND for unforeseen cases an alternative pathway is allowed to the satisfaction of Chief Building Official

0-5% Reduction Credit

Industry Leadership Credits*

- Achieve up to 5% embodied carbon reduction through Industry Leadership Credits detailed in the Embodied Carbon Guidelines.
- Embodied carbon reduction credits are given for optional reporting of a selection of the following
  - Embodied carbon of optional building elements
  - Project-specific estimates for life cycle stages beyond production
  - Use of products with sustainability, transparency, or health certifications
  - Use of circularity practices

* More details will be available in the Embodied Carbon Guidelines. Version 2 will be available for review in Q3 2024

5-10% Whole-building Reduction

2 Pathways*

Year	Absolute Path (kg CO_2/m^2)	Baseline Path
Benchmark	400**	Equivalent Baseline
2023	800	+100%
2025 (Proposed) *If no Industry Leadership Credit pursued (-0%)*	360	-10%
2025 (Proposed) *If maximum Industry Leadership Credit pursued (-5%)*	380	-5%
2027***	TBD	TBD
2030	TBD	-40%

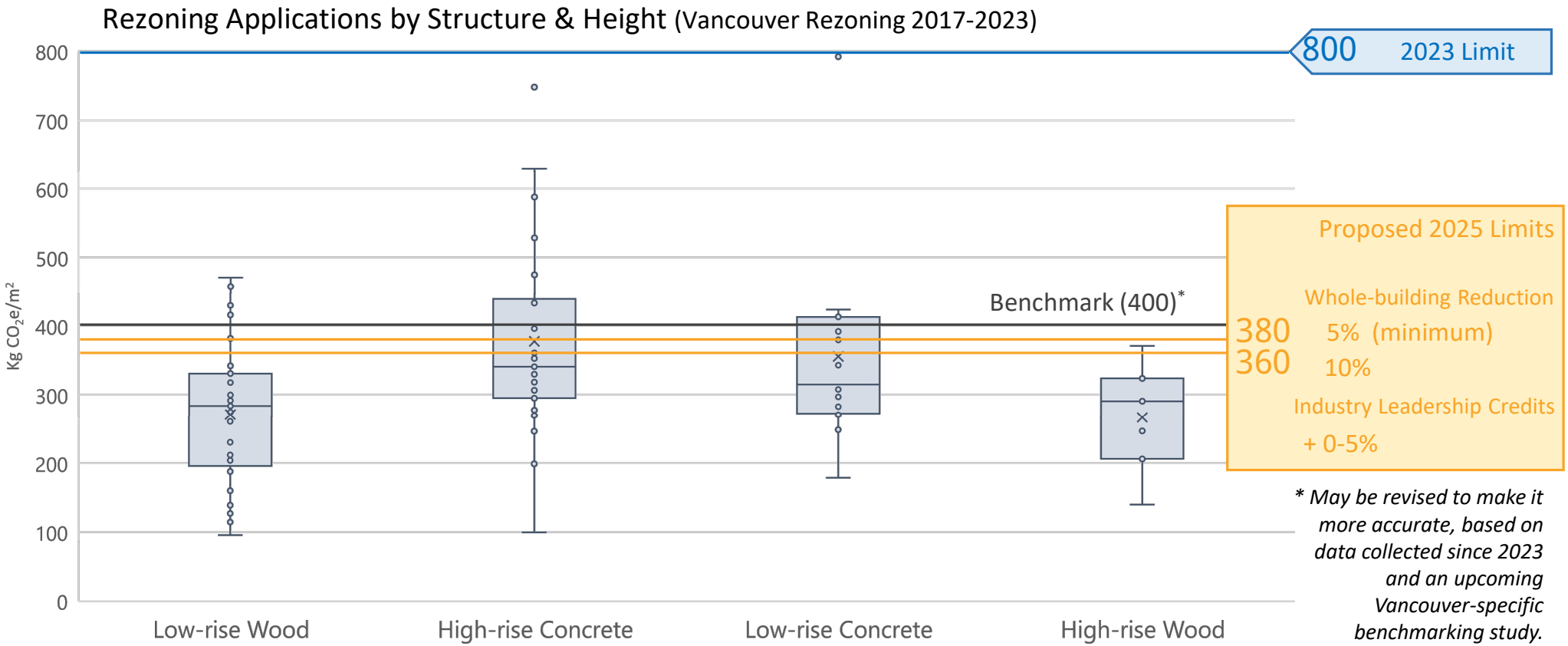
* More details will be available in the Embodied Carbon Guidelines. Version 2 will be available for review in Q3 2024

** May be revised to make it more accurate, based on data collected since 2023 and an upcoming Vancouver-specific benchmarking study.

*** The exact timeline for the next update will be identified based on findings from data collected and consultation with industry and other partners.

5-10% Whole-building Reduction

Absolute Pathway (Proposed Limits, 2025)



** May be revised to make it more accurate, based on data collected since 2023 and an upcoming Vancouver-specific benchmarking study.*

Feedback from Expert Group Consultations

- Keep the code language simple
- Refrain from prescriptive pathways that are not proven to consistently achieve the intended reductions
- Continue requiring and collecting wbLCA data
  - Sets up the industry to prepare for future reduction requirements
  - Informs future policy and reduction targets
- Build Industry Capacity and Provide Clear Guidance

Next Steps for VBBL 2025

Q2 2024

- Implement Initial Feedback
- Publish for Public Review

Q3 2024

- Additional Consultations
- Finalize Code Language
- Publish Embodied Carbon Guidelines Version 2 for review
- Take to Council

Q4 2024

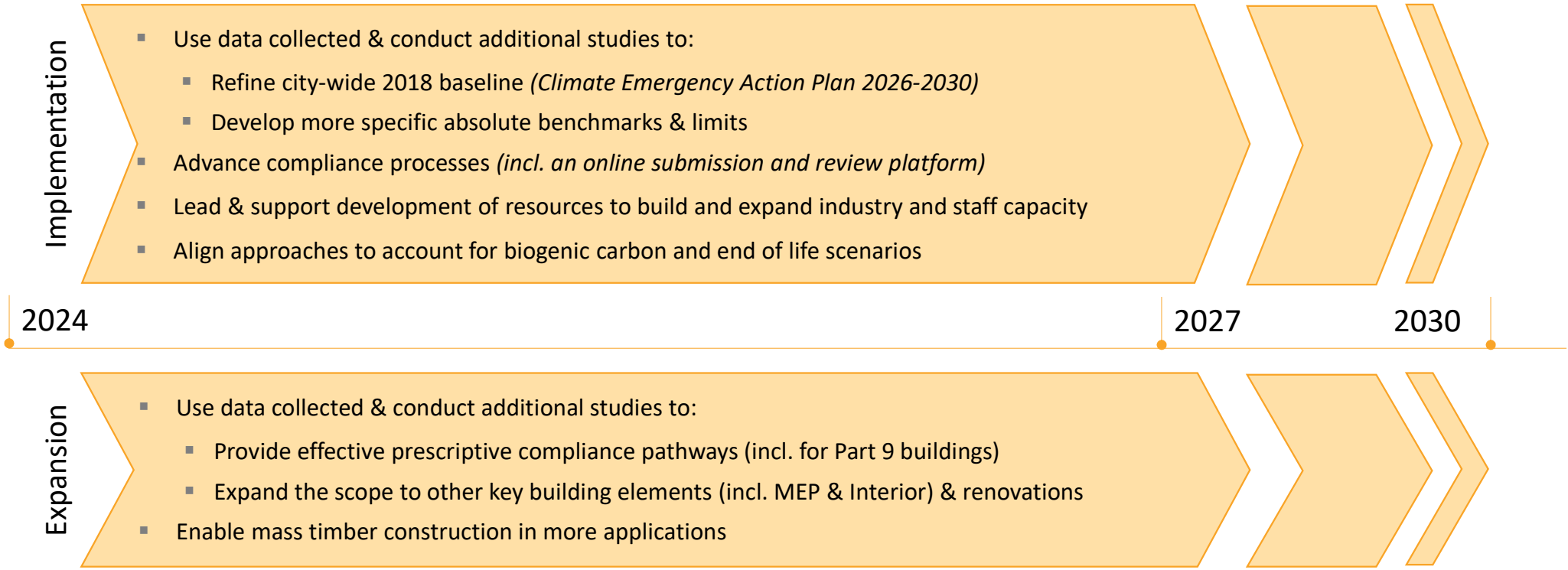
- Finalize & Publish Embodied Carbon Guidelines Version 2

Q1 2025

- VBBL 2025 Effective

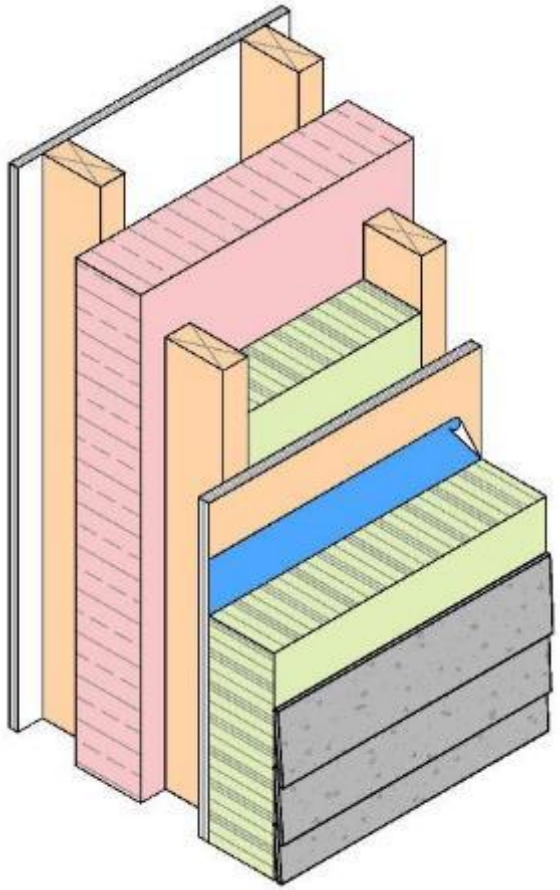
Next Steps for VBBL

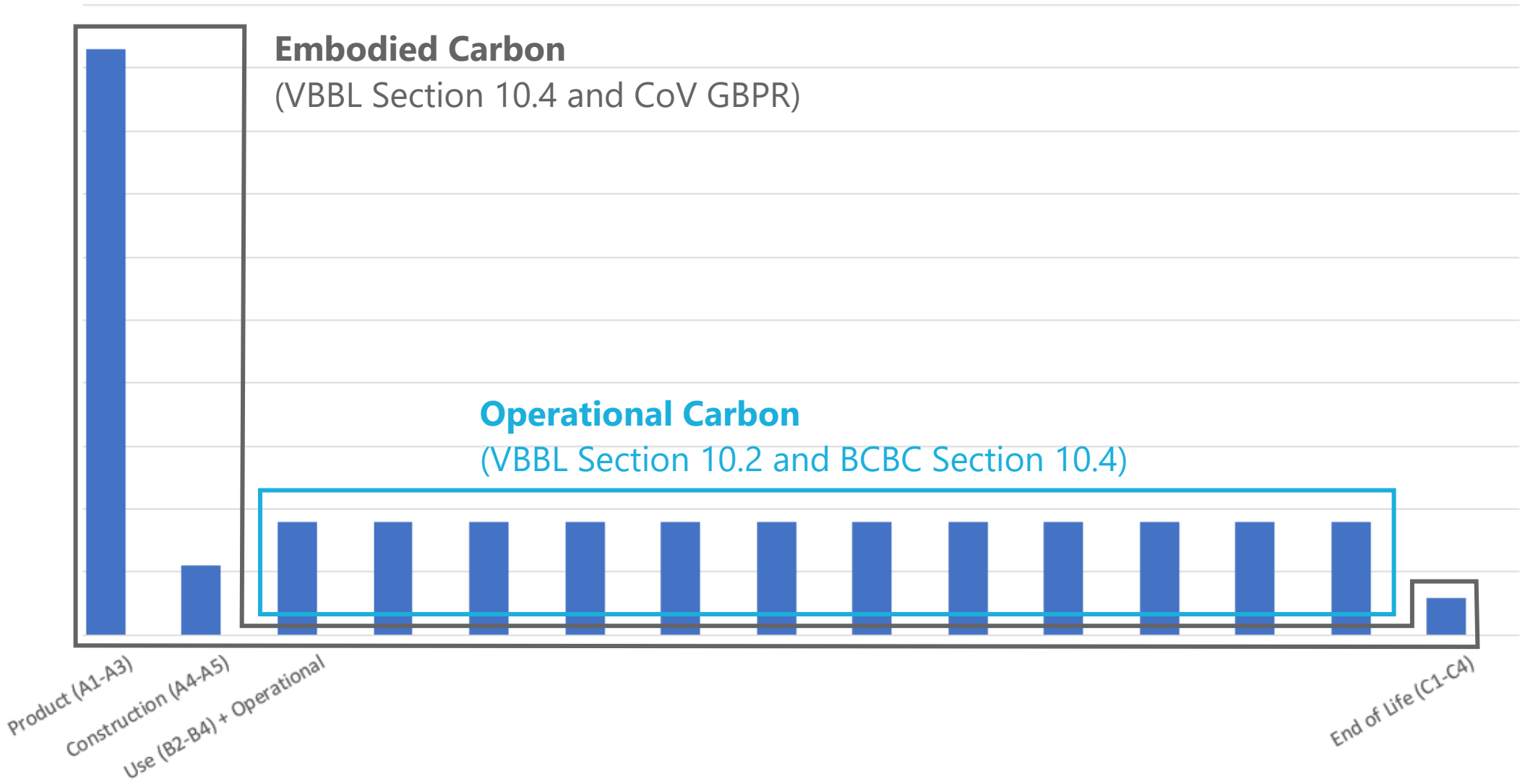
Through Code Acceleration Fund (CAF) provided by Natural Resources Canada (NRCan), Vancouver will work with partners to implement & expand embodied carbon in building code:



Next step beyond ***energy efficient*** *buildings…*

Focus on ***operations*** *and* ***materials***



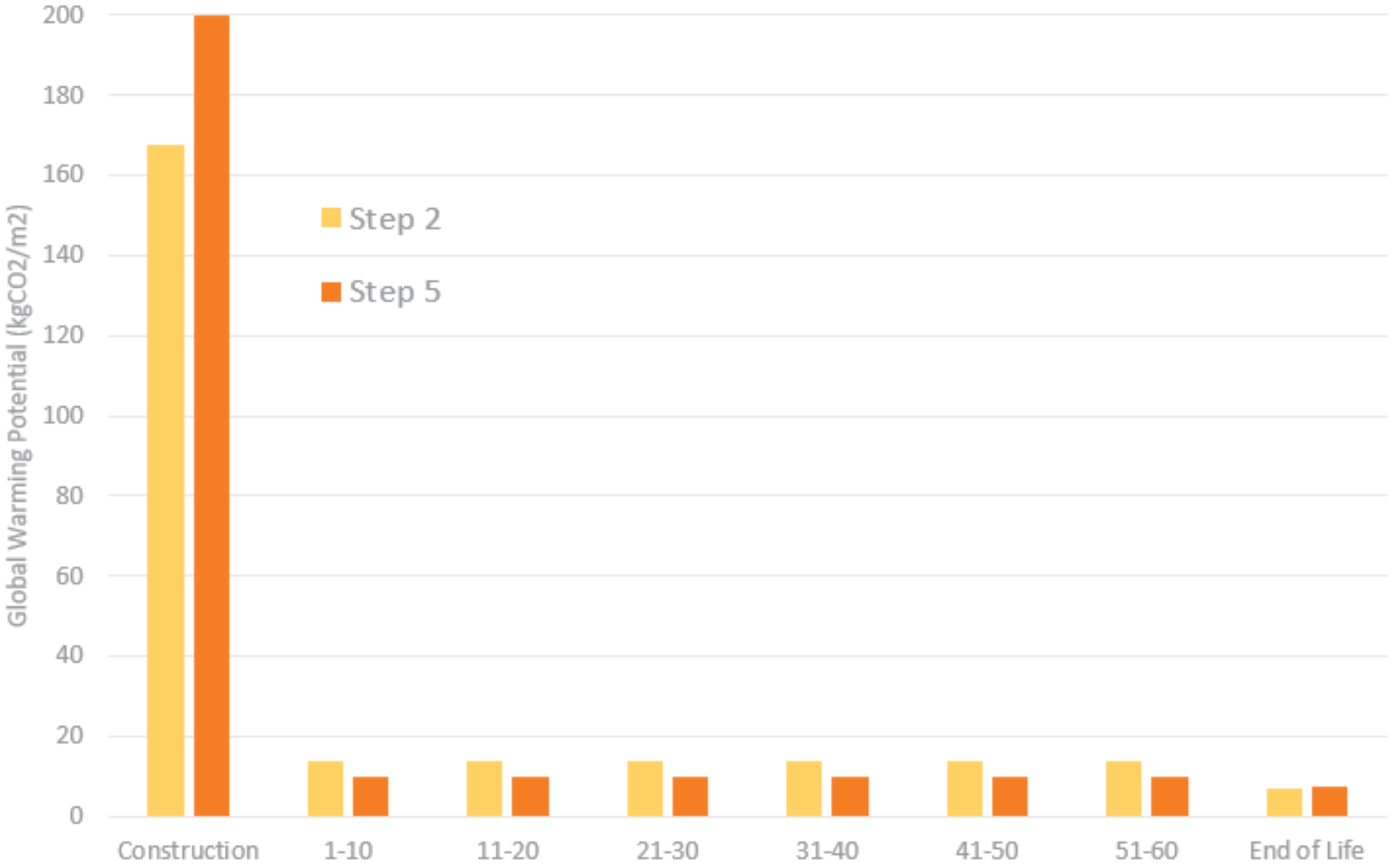

Embodied Carbon
(VBBL Section 10.4 and CoV GBPR)
Operational Carbon
(VBBL Section 10.2 and BCBC Section 10.4)
Product (A1-A3)
Construction (A4-A5)
Use (B2-B4) + Operational
End of Life (C1-C4)

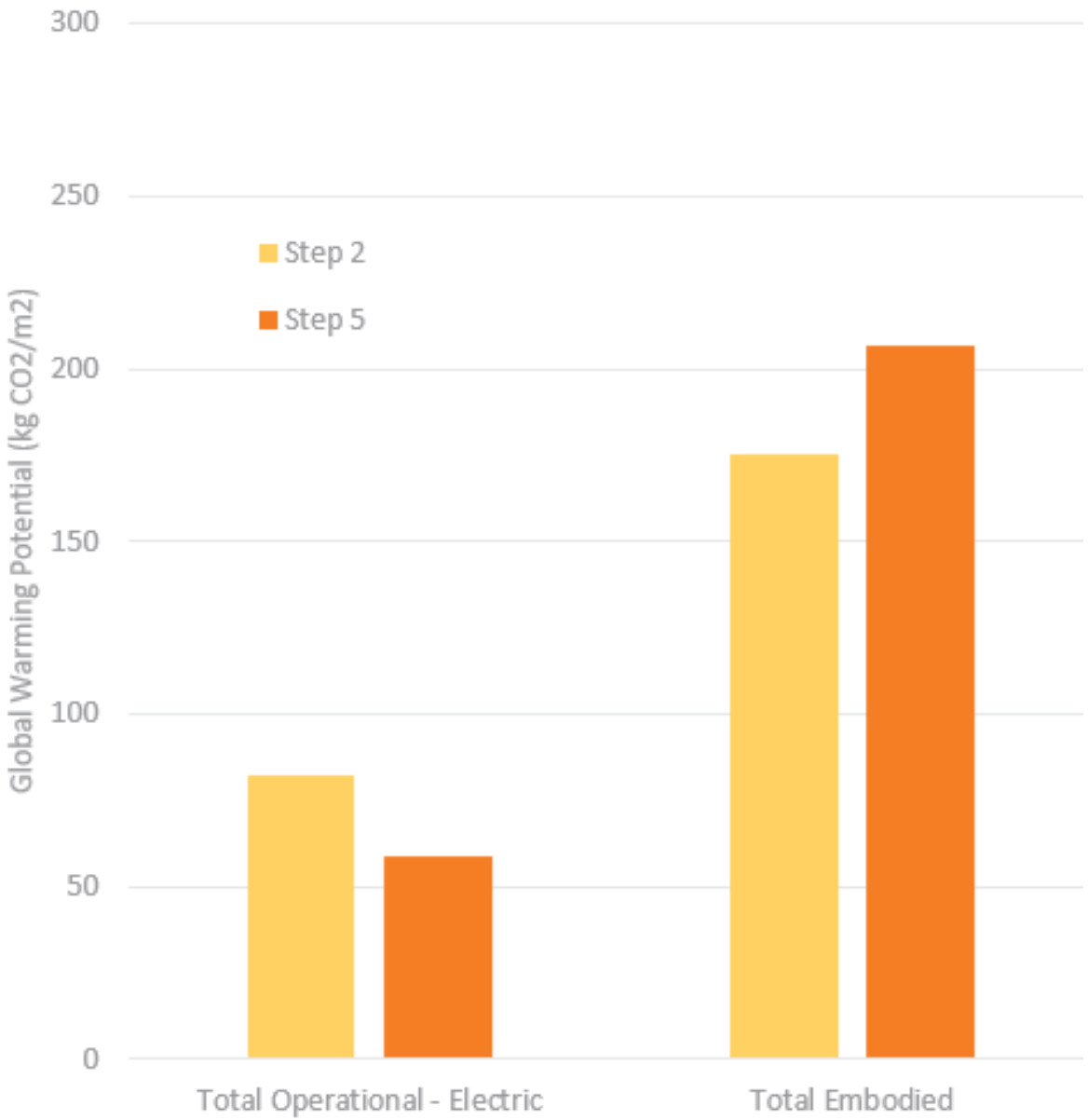
Townhome, Langley

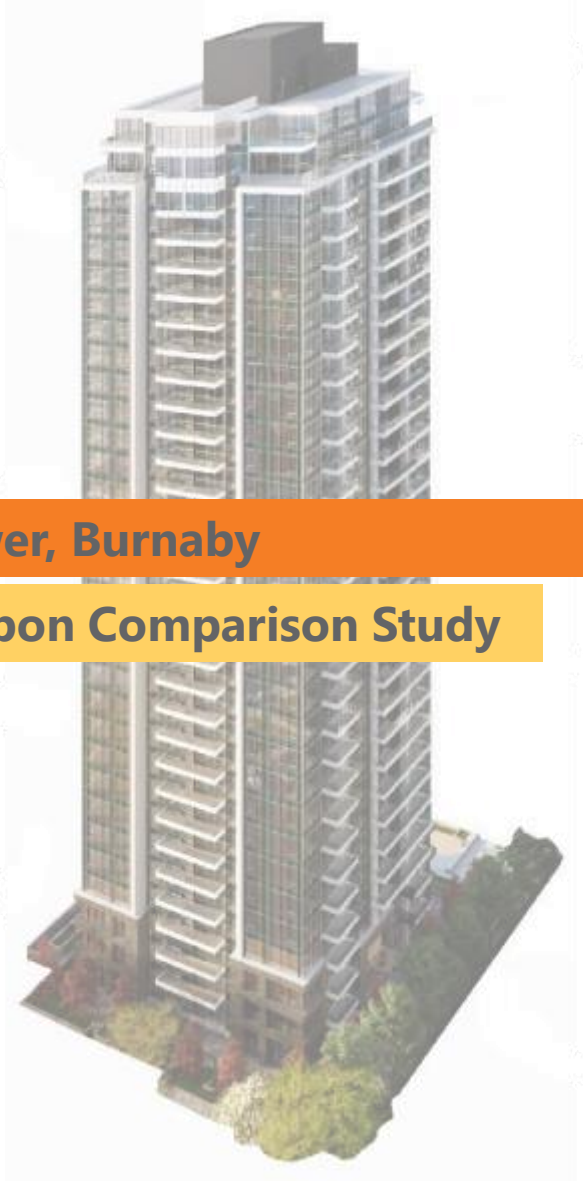
Carbon Comparison Study


R40 Batt
R28 Batt
R22 Batt
Standard
Garage and
Party Walls
R15 XPS
Step 2
Airtightness Target
3.0 ACH @ 50 Pa
Double Glazed
Vinyl Frame
USI 1.4 / SHGC 0.25
No Heat Recovery Ventilator
Natural Gas
Instantaneous
Water Heater
Natural Gas
Condensing Furnace
Air Conditioning
Central Split System


R60 Batt
R40 Batt
R22 Batt
+ 3" Exterior
Sealed
Garage and
Party Walls
R15 XPS
Step 5
Airtightness Target
1.0 ACH @ 50 Pa
Triple Glazed
Vinyl Frame
USI 0.8 / SHGC 0.25
Heat Recovery Ventilator
SRE 80%
Heat Pump
Water Heater
Air Source
Mini-Split
Heat Pump


Global Warming Potential (kgCO2/m2)
200
180
160
140
120
100
80
60
40
20
0
Step 2
Step 5
Construction
1-10
11-20
21-30
31-40
41-50
51-60
End of Life


300
250
200
150
100
50
0
Global Warming Potential (kg CO2/m2)
Step 2
Step 5
Total Operational - Electric
Total Embodied

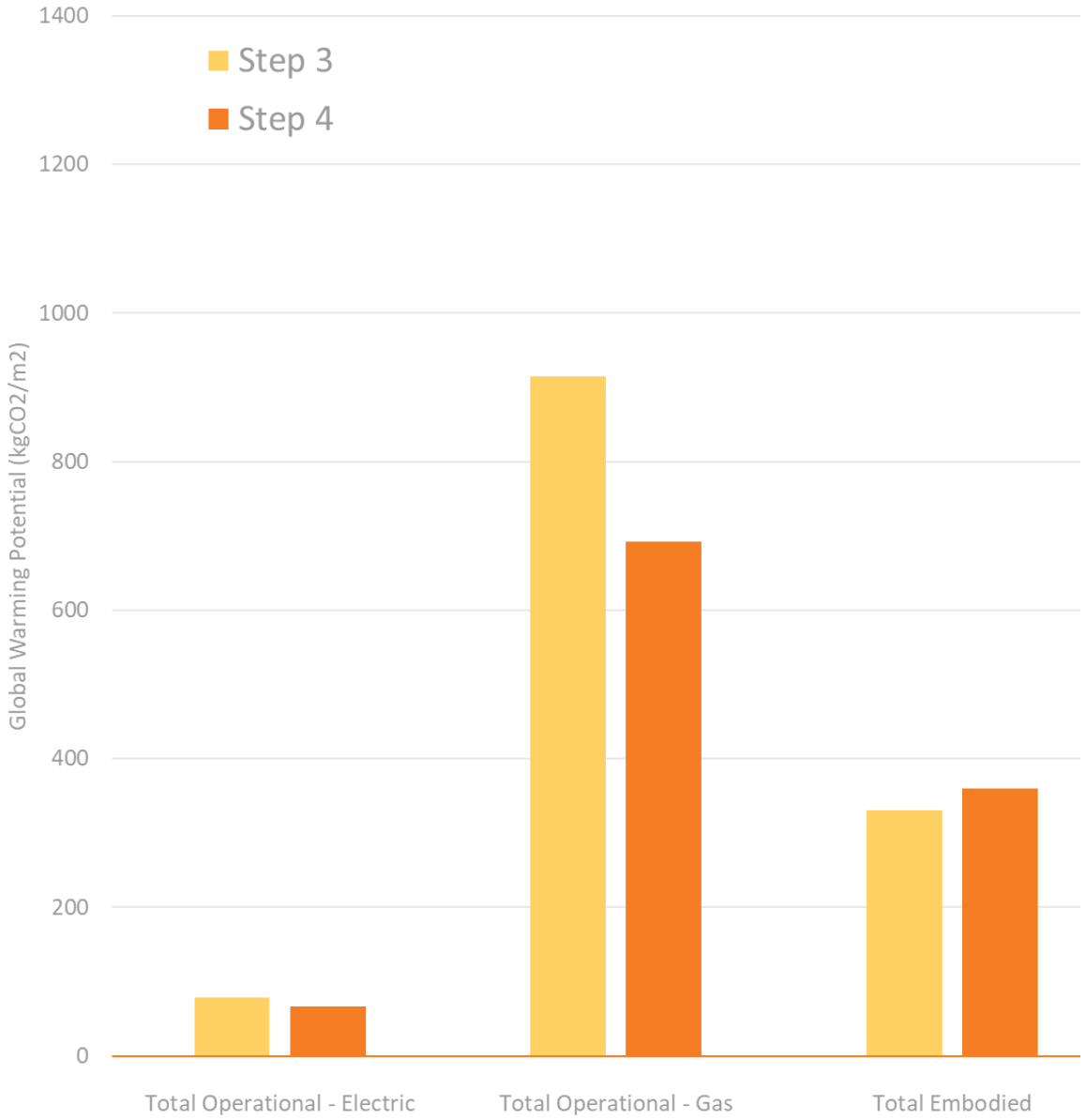


Tower, Burnaby

Carbon Comparison Study


WWR 50%
VFAR 0.50
Airtightness
0.2 L/s/m²
Enhanced DG Aluminum
U0.30
HRV: 78%
Electric Baseboard Heater
4" XPS
Not Thermally Broken
Cavity Batt + 2" Mineral
Wool Continuous
5" Spray
Step 3


WWR 50%
VFAR 0.50
AIRTIGHTNESS
Infiltration 0.15 L/s/m²
Enhanced TG Aluminum
U0.23
HRV: 88%
Heat Pump
8" XPS
Thermally Broken
Cavity Batt + 6" Mineral
Wool Continuous
6" Spray
Step 4


1400
1200
1000
800
600
400
200
0
Global Warming Potential (kgCO2/m2)
Step 3
Step 4
Total Operational - Electric
Total Operational - Gas
Total Embodied

BC Building Science

We are a professional engineering firm, specializing in building envelope **durability** and energy **efficiency** over buildings' **lifespans**.

VBBL 2025 Embodied Carbon Regulations

CLF BC Workshop

May 6, 2024

ZGF

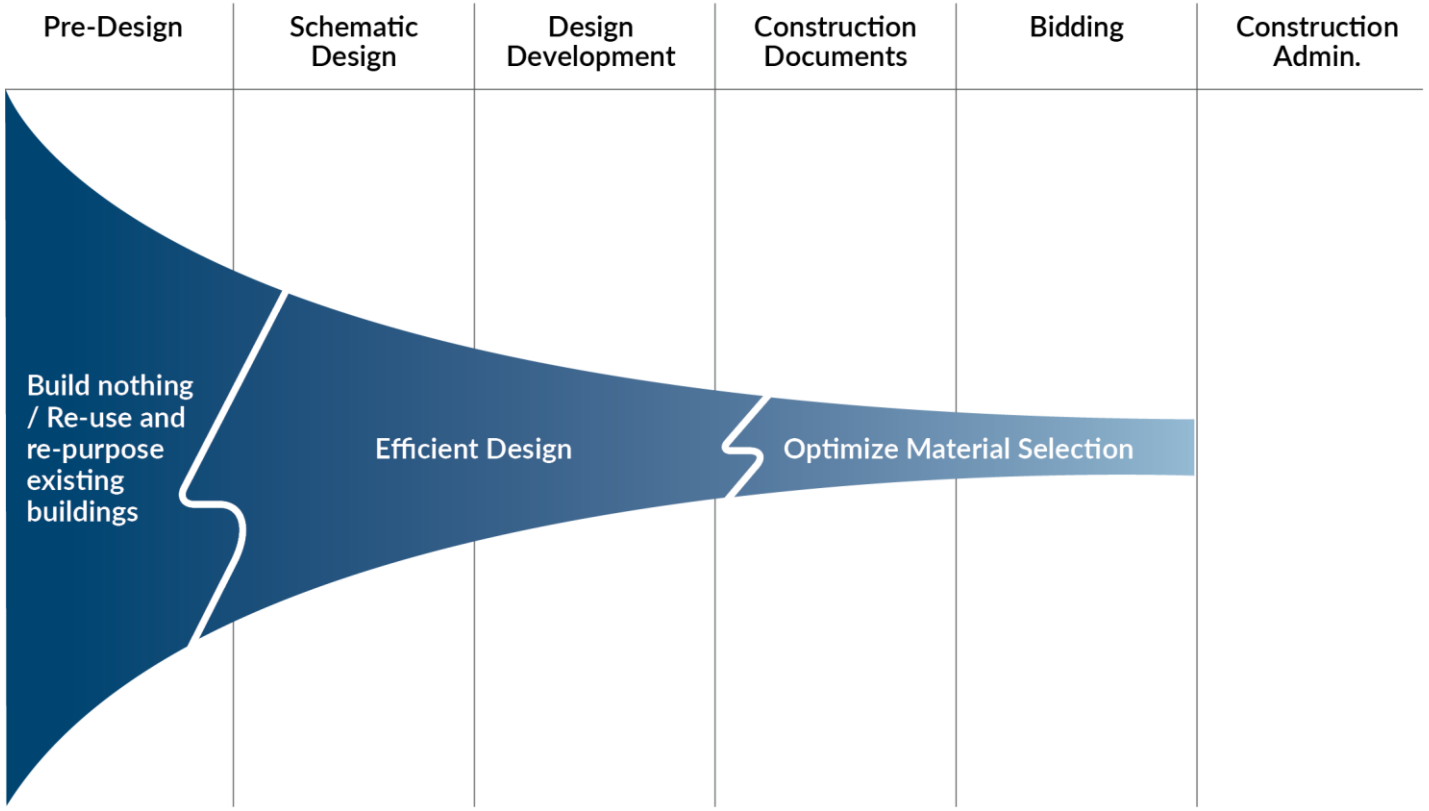
ZGF Embodied Carbon Experience

Iain MacFadyen & Ayme Sharma

ZGF

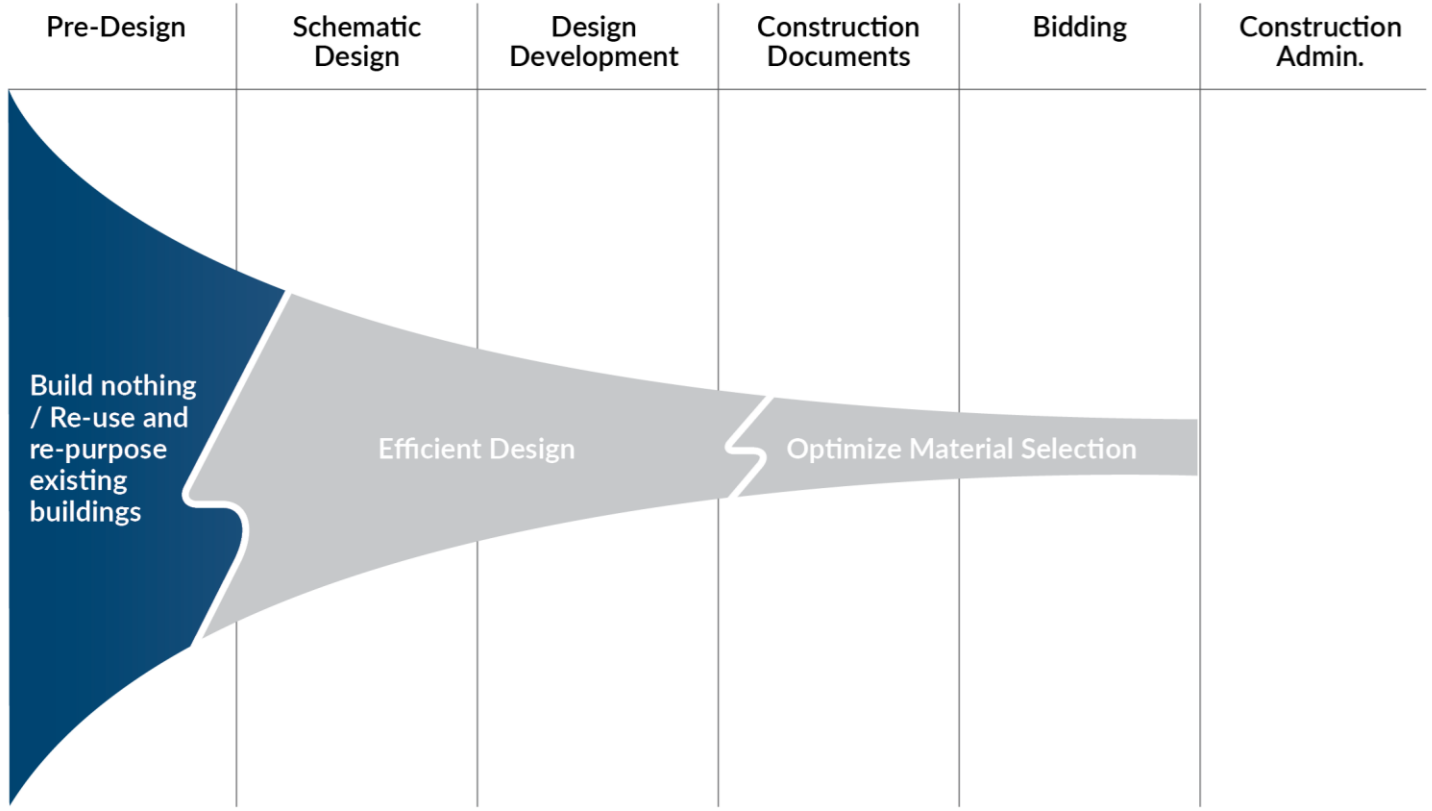
Scale of Impact

Range of opportunities at each stage of the project with varying degrees of scale of impact.



Scale of Impact

Range of opportunities at each stage of the project with varying degrees of scale of impact.

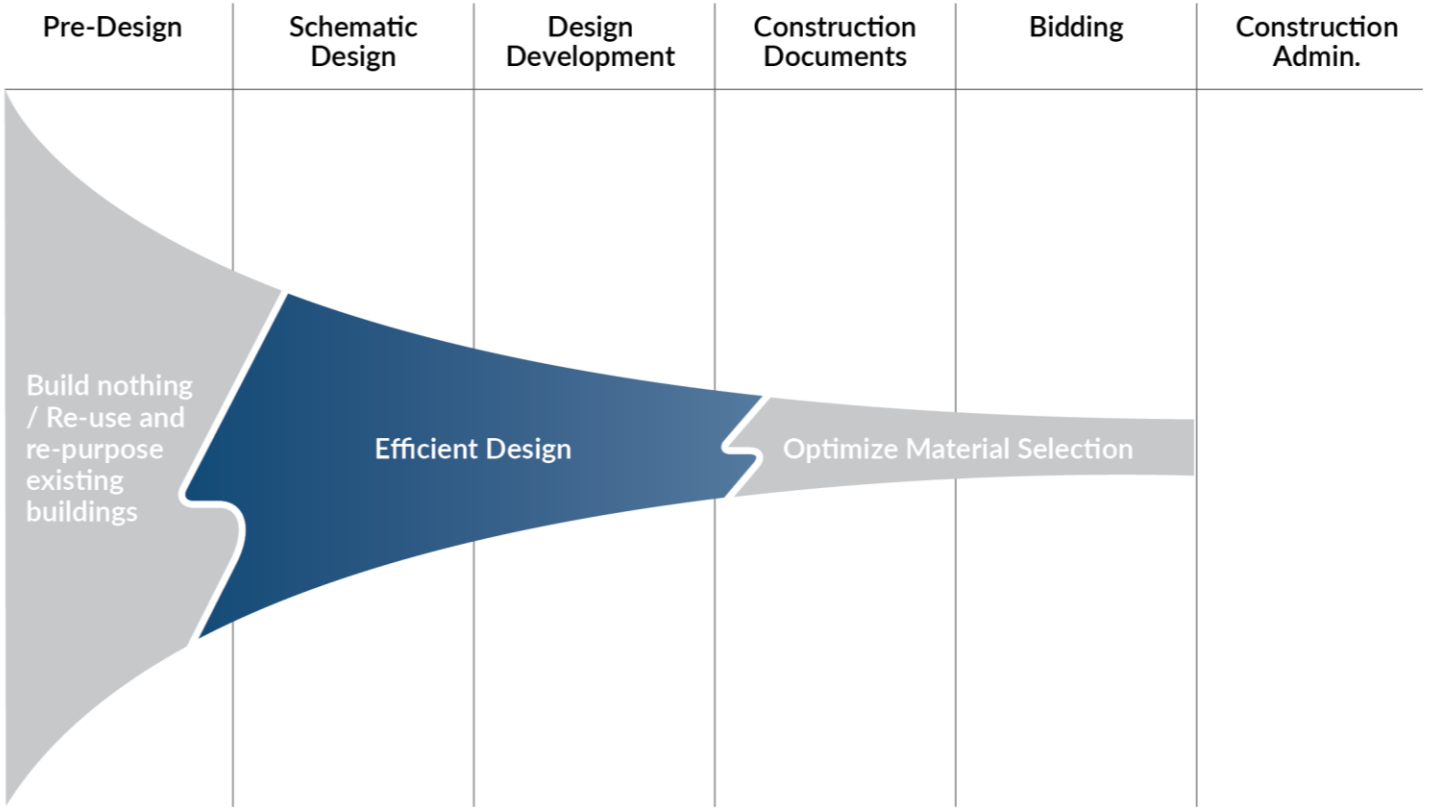


Build Nothing / Re-use

Scale of Impact

Range of opportunities at each stage of the project with varying degrees of scale of impact.

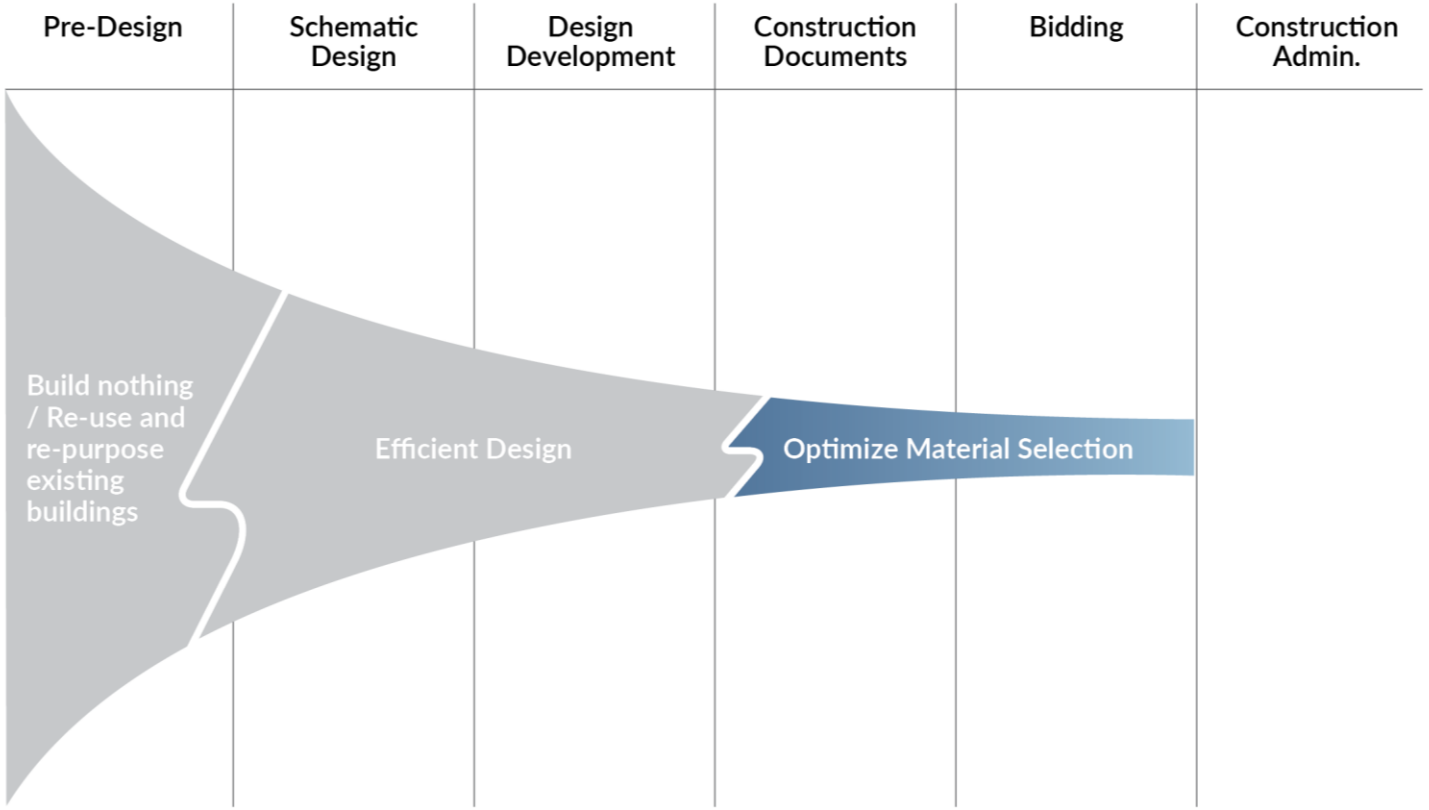
Efficient Design



Scale of Impact

Range of opportunities at each stage of the project with varying degrees of scale of impact.

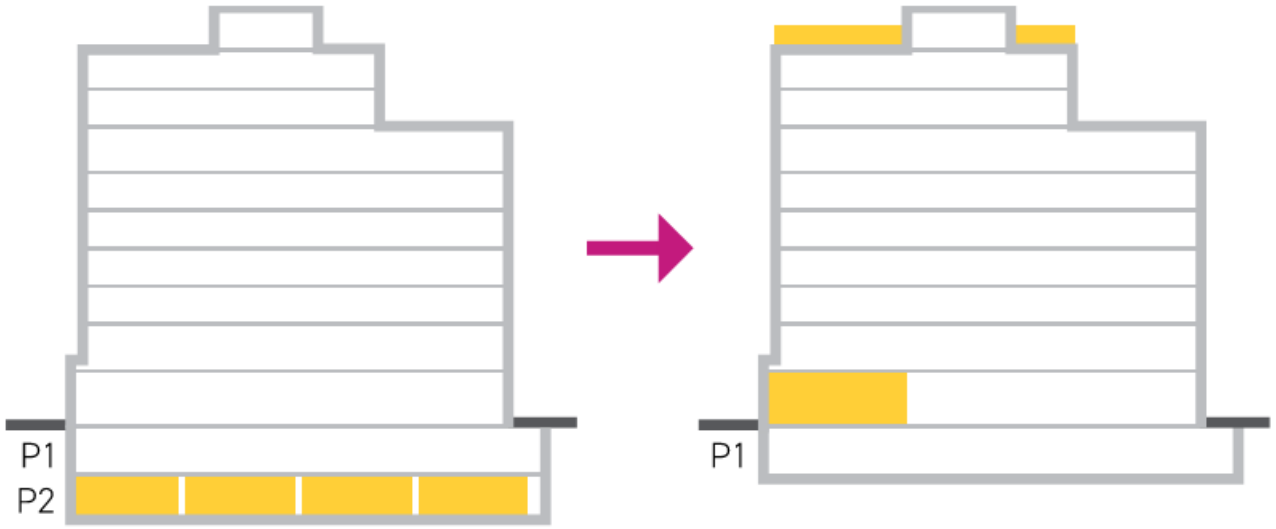
Optimize Material Selection



Case Studies

Example: VAHA Seymour

Efficient Design: Concrete Volume Reduction

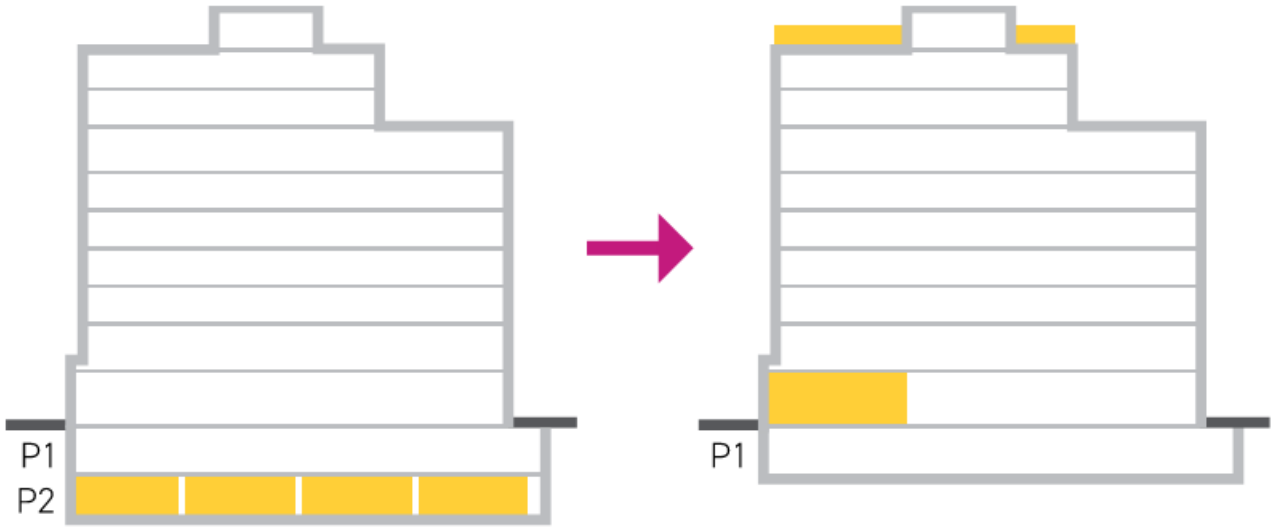


Parkade

9% reduction on the overall LCA

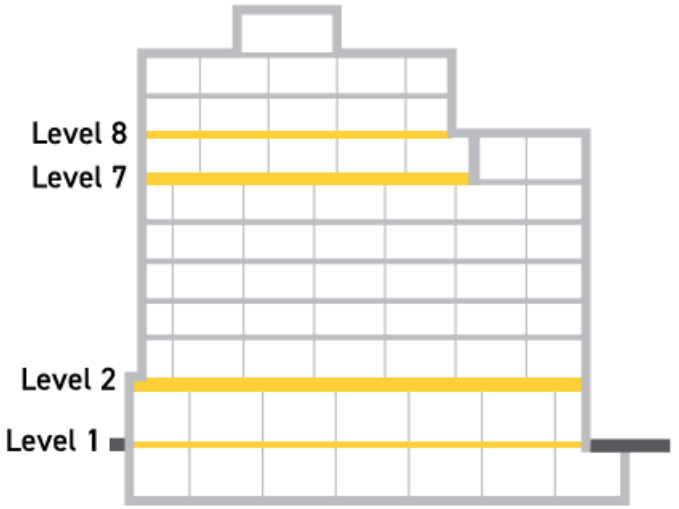
Example: VAHA Seymour

Efficient Design: Concrete Volume Reduction



Parkade

9% reduction on the overall LCA

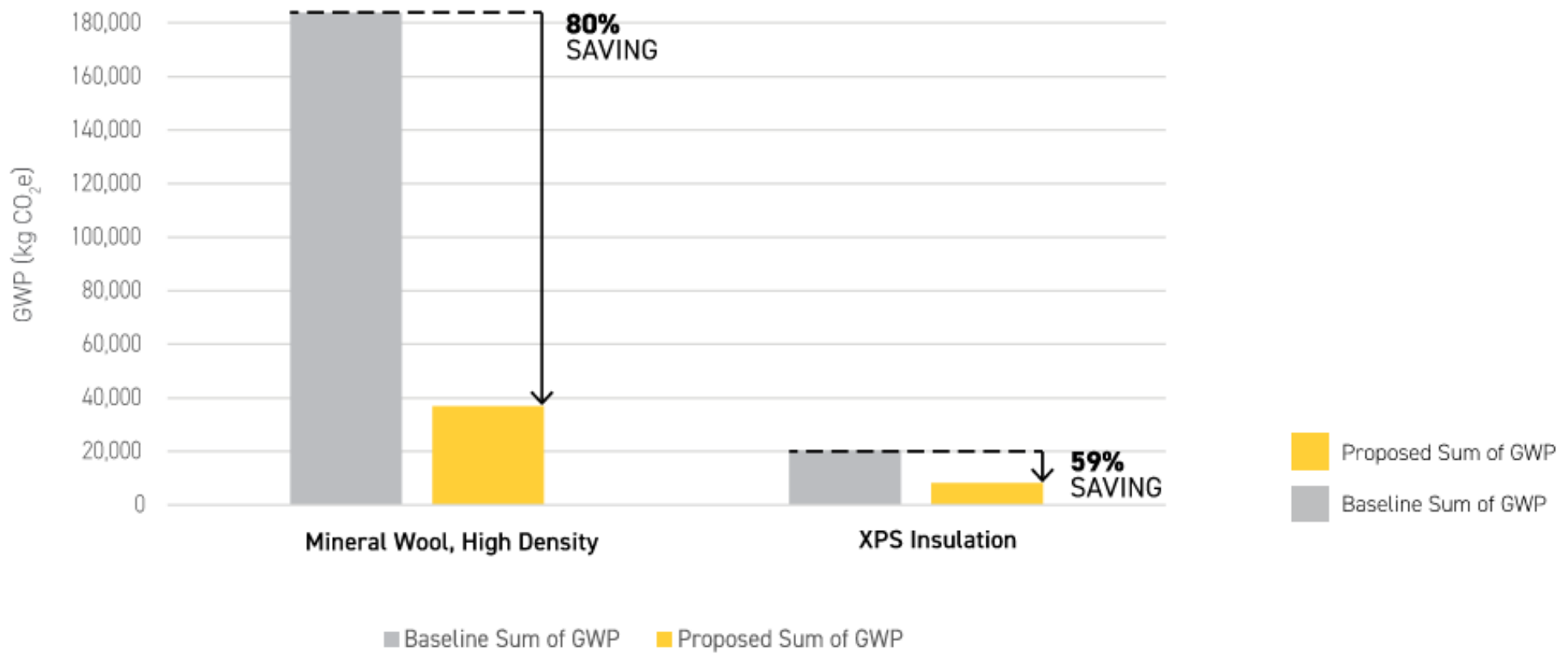


Structure Optimization

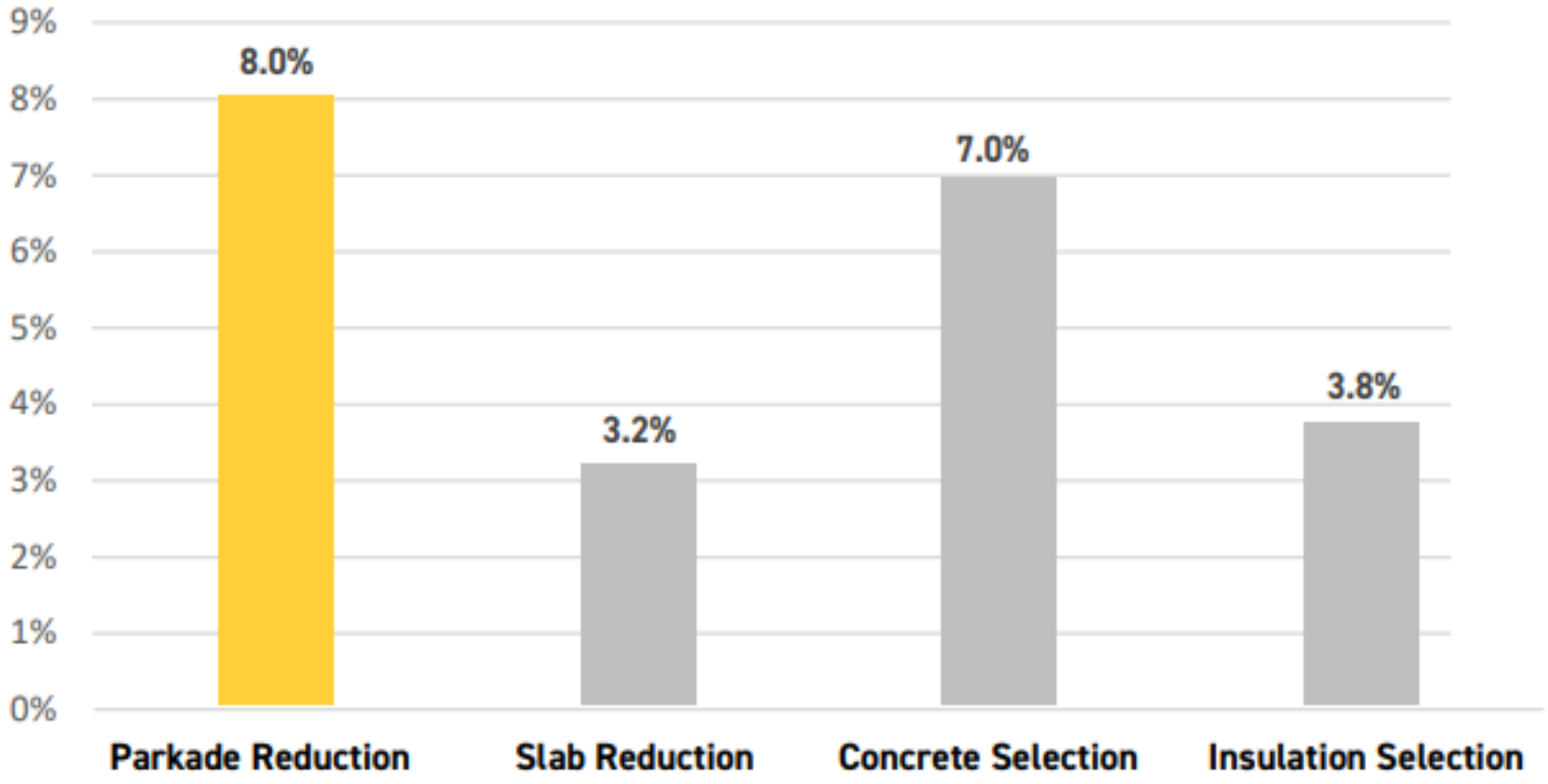
3% reduction on the overall LCA

Example: VAHA Seymour

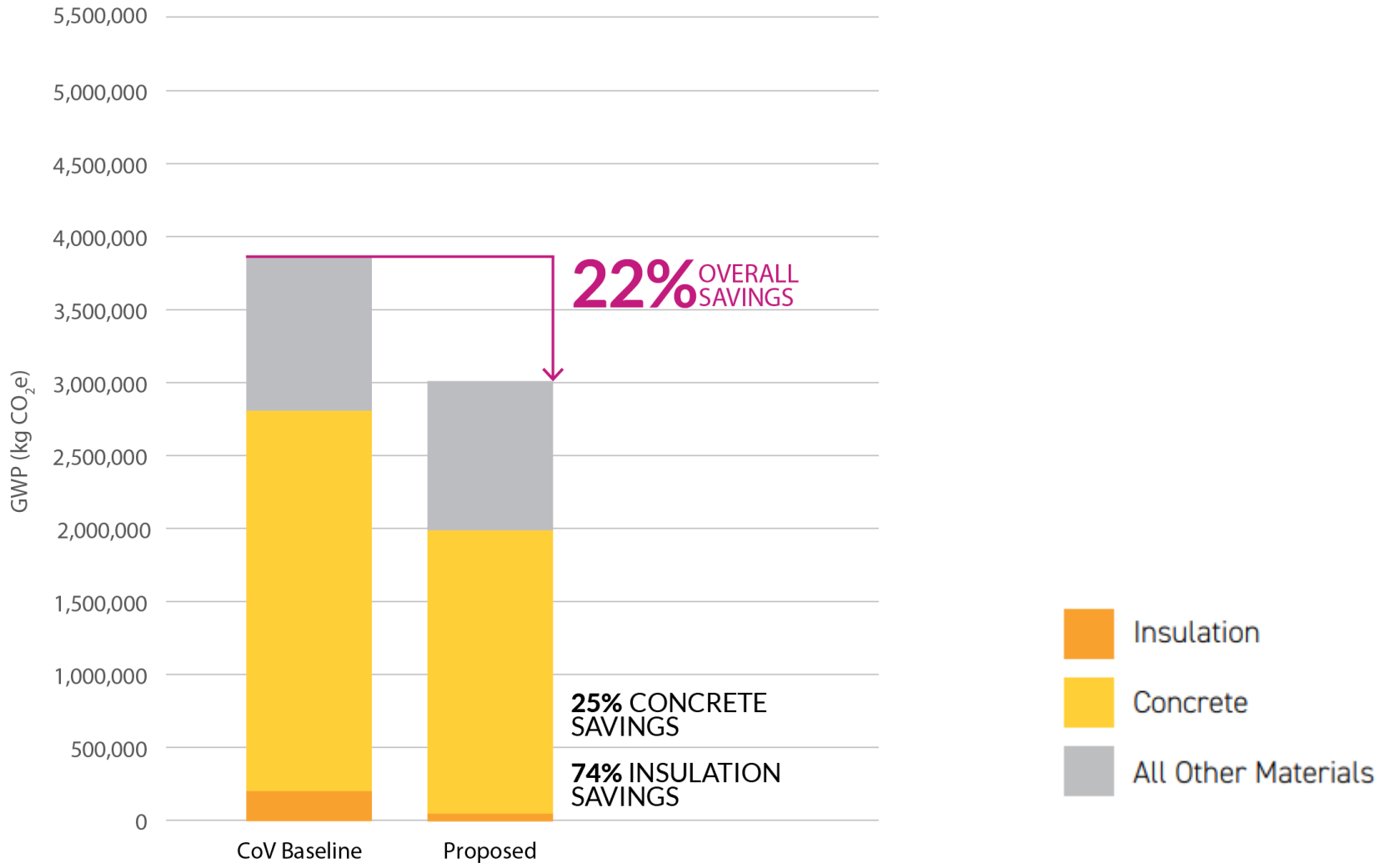
Optimizing Material Selection: Insulation



Example: VAHA Seymour



Example: VAHA Seymour




CLARK

Example: Office Tower, Surrey

Elements	Exposure Class	Nominal Max Aggregate Size (As per CSA A23.1)	3 Day (stripping) Strength Min (MPa)	28 Day Strength Min (MPa)	56 Day Strength Min (MPa)	Baseline (kgCo2eq/m3)	Option 1 Standard Mix (kgCo2eq/m3)	Option 2 $ (kgCo2eq/m3)	Option 3 $$ (kgCo2eq/m3)
Pad and Strip footings	N	1"		30	35	259	192	176	153
Core Footing	C-1	1"			40	344	301	273	199
Foundation Walls	F-2	.75"		35		311	252	219	175
Ramp Walls	C-1	.75"		35		311	263	224	166
Shear Walls (P4-P1)	C-1	.75"		55		402	300	285	N/A
Shear Walls (L1-L3)	N	.75"			55	377	290	262	N/A
Shear Walls (L4-Roof)	N	.75"			45	335	275	250	185
Interior slab-on-grade	C-4	.75"			30	259	230	176	145
Columns	Interior L3-Roof	.75"			50	359	275	250	192
	Interior L1-u/s L3	.75"			50	359	275	250	192
	Parking P4-u/s L1	.75"			45	335	260	237	185
Parking Slabs (P3, P2)	C-1	.75"	**25**	35		311	304	N/A	N/A
P1 (non parking areas)	N	.75"	**25**	40		329	297	N/A	N/A
P1 (parking areas)	C-1	.75"	**25**	40		344	304	N/A	N/A
L1	N	.75"	**25**	40		329	297	N/A	N/A
L2-Roof	N	.75"	**25**	35		329	297	N/A	N/A
							3,670,009.2	3,545,731.82	2,596,622.35
							12.1%	**15.1%**	**37.8%**

Example: Office Tower, Surrey

Elements	Exposure Class	Nominal Max Aggregate Size (As per CSA A23.1)	3 Day (stripping) Strength Min (MPa)	28 Day Strength Min (MPa)	56 Day Strength Min (MPa)	Baseline (kgCo2eq/m3)	Option 1 Standard Mix (kgCo2eq/m3)	Option 2 $ (kgCo2eq/m3)	Option 3 $$ (kgCo2eq/m3)
Pad and Strip footings	N	1"		30	35	259	192	176	153
Core Footing	C-1	1"			40	344	301	273	199
Foundation Walls	F-2	.75"		35		311	252	219	175
Ramp Walls	C-1	.75"		35		311	263	224	166
Shear Walls (P4-P1)	C-1	.75"		55		402	300	285	N/A
Shear Walls (L1-L3)	N	.75"			55	377	290	262	N/A
Shear Walls (L4-Roof)	N	.75"			45	335	275	250	185
Interior slab-on-grade	C-4	.75"			30	259	230	176	145
Columns	Interior L3-Roof	.75"			50	359	275	250	192
	Interior L1-u/s L3	.75"			50	359	275	250	192
	Parking P4-u/s L1	.75"			45	335	260	237	185
Parking Slabs (P3, P2)	C-1	.75"	25	35		311	304	N/A	N/A
P1 (non parking areas)	N	.75"	25	40		329	297	N/A	N/A
P1 (parking areas)	C-1	.75"	25	40		344	304	N/A	N/A
L1	N	.75"	25	40		329	297	N/A	N/A
L2-Roof	N	.75"	25	35		329	297	N/A	N/A
							3,670,009.2	3,545,731.82	2,596,622.35
							12.1%	15.1%	37.8%

Example: Office Tower, Surrey

Elements	Exposure Class	Nominal Max Aggregate Size (As per CSA A23.1)	3 Day (stripping) Strength Min (MPa)	28 Day Strength Min (MPa)	56 Day Strength Min (MPa)	Baseline (kgCo2eq/m3)	Option 1 Standard Mix (kgCo2eq/m3)	Option 2 $ (kgCo2eq/m3)	Option 3 $$ (kgCo2eq/m3)
Pad and Strip footings	N	1"		30	35	259	192	176	153
Core Footing	C-1	1"			40	344	301	273	199
Foundation Walls	F-2	.75"		35		311	252	219	175
Ramp Walls	C-1	.75"		35		311	263	224	166
Shear Walls (P4-P1)	C-1	.75"		55		402	300	285	N/A
Shear Walls (L1-L3)	N	.75"			55	377	290	262	N/A
Shear Walls (L4-Roof)	N	.75"			45	335	275	250	185
Interior slab-on-grade	C-4	.75"			30	259	230	176	145
Columns	Interior L3-Roof	.75"			50	359	275	250	192
	Interior L1-u/s L3	.75"			50	359	275	250	192
	Parking P4-u/s L1	.75"			45	335	260	237	185
Parking Slabs (P3, P2)	C-1	.75"	25	35		311	304	N/A	N/A
P1 (non parking areas)	N	.75"	25	40		329	297	N/A	N/A
P1 (parking areas)	C-1	.75"	25	40		344	304	N/A	N/A
L1	N	.75"	25	40		329	297	N/A	N/A
L2-Roof	N	.75"	25	35		329	297	N/A	N/A
							3,670,009.2	3,545,731.82	2,596,622.35
							12.1%	**15.1%**	**37.8%**

Thank You

ZGF

May 6th, 2024

Contractor's Perspective

on the proposed 2025 VBBL updates

Phoebe Cullingham,
Climate & Sustainability Manager

EllisDon

Our Climate Commitment

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

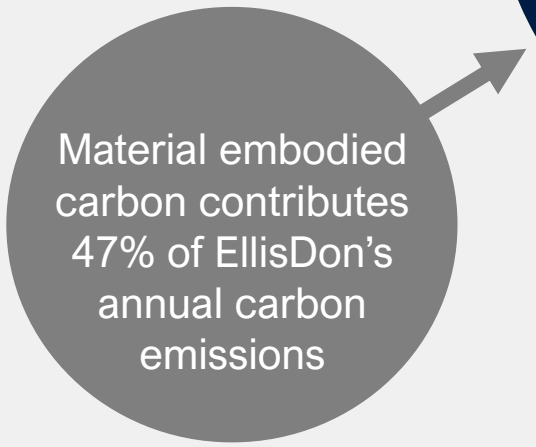
Net Zero by 2050

Min 42% absolute reduction by 2030

- Direct & Indirect emissions
- Construction activities
- Building materials
- Operational energy

Must rely on reduction strategies (not offsets)

Material embodied carbon contributes 47% of EllisDon's annual carbon emissions

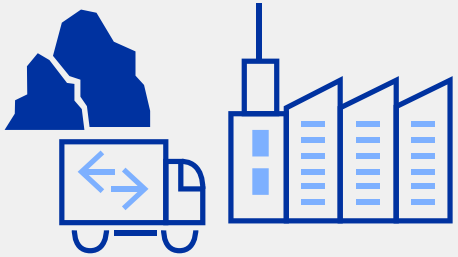


EllisDon

Emissions in the Built Environment

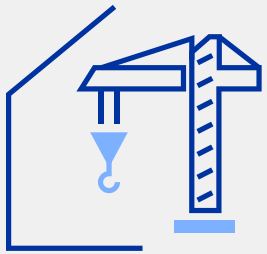
PRODUCT

Raw material supply | Manufacturing



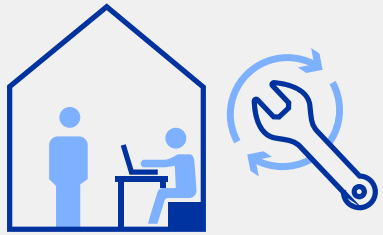
CONSTRUCTION

Transportation and construction



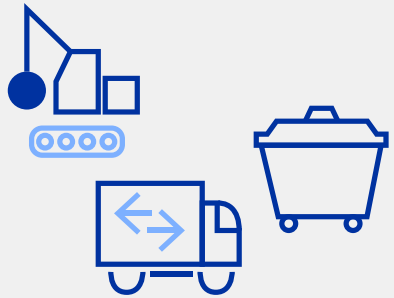
USE

Operations | Maintenance and repair



END-OF-LIFE

Deconstruction /demolition | Waste processing, disposal



Operational Carbon

Embodied Carbon

Image source: Building Performance Institute Europe (BPIE), Roadmap to Climate-Proof Buildings and Construction (2022)

Concrete Specification Development

Specifications should be performance based, not prescriptive.

- Mandate a volume-averaged carbon reduction over a baseline
- Require plant specific EPDs be submitted
- Avoid referencing specific technologies

2.02 PERFORMANCE CRITERIA

SPEC NOTE: When selecting Alternative 1 - Performance Method, use the following article and paragraph.

.1 Quality Control Plan: Ensure concrete supplier meets performance criteria of concrete as established by [Departmental Representative] [DCC Representative] [Consultant] and provide verification of compliance as described in QUALITY ASSURANCE in Part 1 of this Section.

.2 Provide supplementary cementitious materials and products that contribute to a [10] [15] [20] % reduction in the Global Warming Potential (GWP) against the listed GWP identified in the industry-wide EPD and a reduction in the environmental impact categories as measured through a cradle-to-gate scope.

NRC's National Master Specification

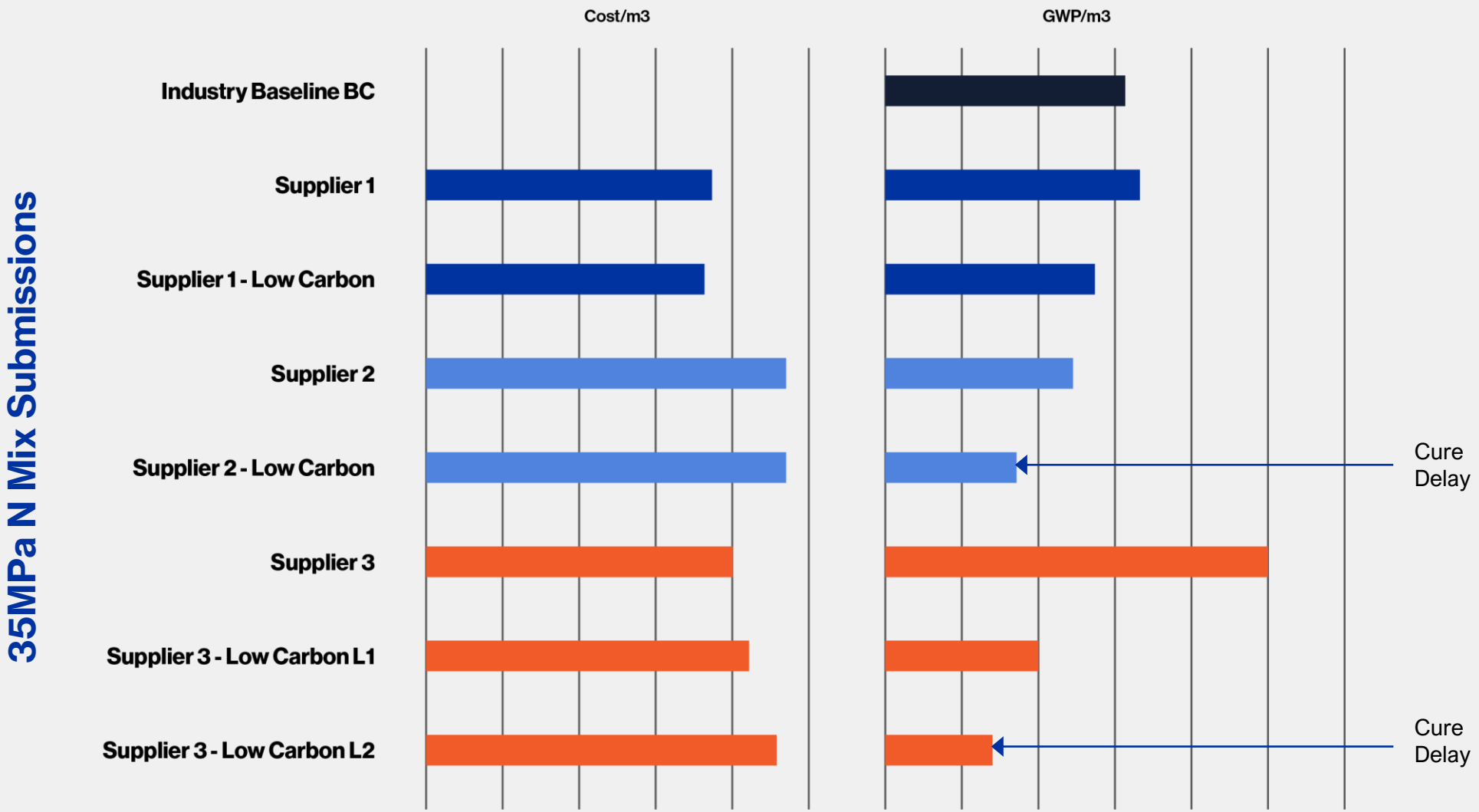
Concrete Procurement

Project Name - Concrete Embodied Carbon Bid Form

Bidder: | Can you produce verified plant specific (Type III) EPDs: | Global reduction target: 15%

Design					Concrete Mix 1 (Low Carbon)					Concrete Mix 2 (Lower Carbon)						ELLISDON USE ONLY			
Element	Mix	Volume m3	Regional Baseline GWP	Baseline carbon kgCO2e	Proposed GWP kgCO2e	Strength at age	Cost $/m3	Proposed carbon kg	Carbon reduction	Proposed GWP kgCO2e	Strength at age	Cost $/m3	Proposed carbon kg	Carbon saved kg	Carbon reduction	Mix	Cost $	Carbon kg	Carbon Reduction
Slab on Grade	25 N	860	254.05	218483	225	28		193500	*11%*	190	56		163400	55083	*25%*	Mix 2	0	163400	25%
Foundations	30 N	1798	264.38	475355	235	28		422530	*11%*	198	56		356004	119351	*25%*	Mix 2	0	356004	25%
Beams	30 F-1	358	292.72	104794	270	28		96660	*8%*	236	56		84488	20306	*19%*	Mix 1	0	96660	8%
Slabs	35 N	5673	295.46	1676145	260	28		1474980	*12%*	230	56		1304790	371355	*22%*	Mix 1	0	1474980	12%
Columns	50 N	210	335.76	70510	305	56		64050	*9%*	270	56		56700	13810	*20%*	Mix 2	0	56700	20%
				0				0	*0%*				0	0	*0%*				
Total				*2545286*	*1295*			*2251720*	***12%***	*1124*			*1965382*	*579904*	***23%***		*0*	*2147744*	**16%**

Supplier Differences



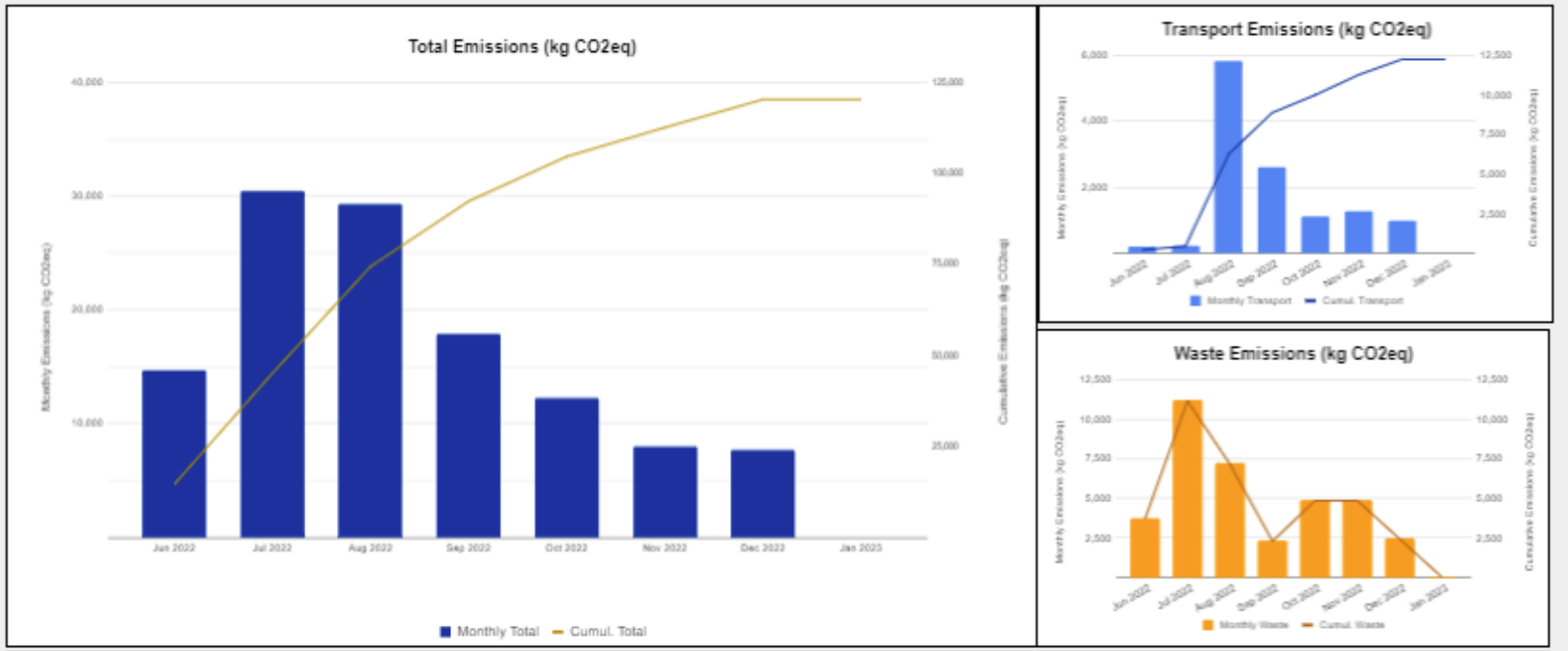
Other Material Procurement

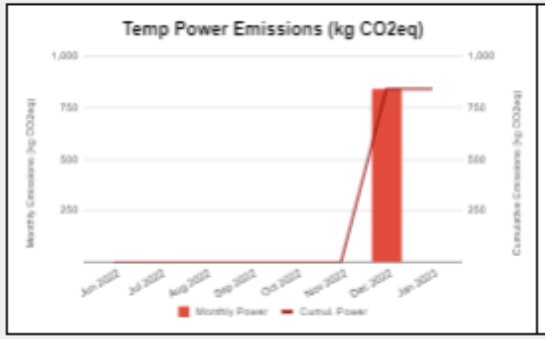
- Metal mills, brokers, and fabricators are advancing the accessibility of carbon data
- Other material products (insulation, glazing, etc) should be considered during design to reduce volumes, hard to optimize in procurement
    - As industry advances, this will change
- Specifications could include reference to "(%%) better than industry average"
- The more explicit documentation asks are made in specs, the more documentation will be readily available
- Product specific data is required to demonstrate reductions from a baseline

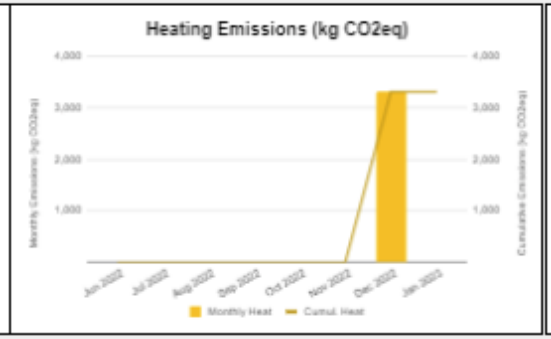
Transportation & Installation (A4-A5)

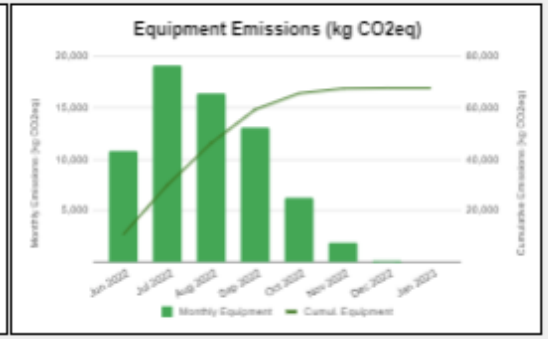
- "Construction Stage" data is very weak in the industry, relies on estimated factors
  - CoV wishes to better understand these real-world impacts and is incentivizing projects to track and disclose
  - When combined with other initiative, up to 5% "leadership credit" is available

- EllisDon is running pilot projects around the country tracking on-site emissions
  - Deliveries to site (A4), Fuel/power used on site (A5)
  - In contract, tie monthly billing to data submission from trades
  - Data collection can be streamlined with logistics software









Emissions by Year and Category (kg CO2eq)

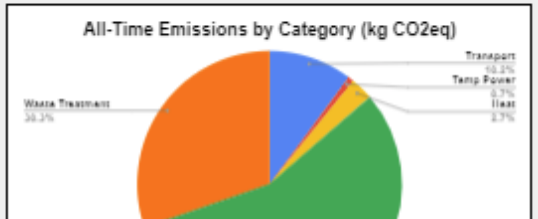
	Transport	Waste	Temp Power	Heating	Equipment	All Emissions
2022	12,248	38,431	840	3,304	67,528	120,352
2023	0	0	0	0	0	0
2024	0	0	0	0	0	0
TOTAL	12,248	38,431	840	3,304	67,528	120,352

Choose Date Range for Above Charts

Date Range to use above: Custom

Standard:start date to prevent. Custom: enter below (MM/YYYY)

Standard Start:	06/2022	Custom Start:	06/2022
Standard End:	06/2023	Custom End:	1/2023



A4 and A5 Emissions (for comparison to Building LCA)

A4 Emissions (Transport to Site)

Total emissions, deliveries (material & equipment)	3,820	Select the Excavation Trade	ABC Foundation Inc
Less delivery emissions from excavation subtrade	598	Select the Demolition Trade	XYZ Demo Ltd
Less delivery emissions from demo subtrade	266		
Total A4 Emissions	2,956 kg CO2eq		

A5 Emissions (Construction Installation Process)

Total emissions, site removals (Waste & Soil)	8,428
Less removal emissions from excavation subtrade	7,758
Less removal emissions from demo subtrade	266

- Can also help owners & project teams identify carbon “hot spots”
- Invest in the most impact ways to reduce carbon
- Initiate policies to reduce carbon wastage (anti-idling, battery power, faster grid connections, formwork heating, etc)

EllisDon

LAFARGE

CLF BC VBBL 2025 Embodied Carbon

May 6, 2024
Matt Dalkie
Senior Sustainability Manager

A MEMBER OF HOLCIM GROUP

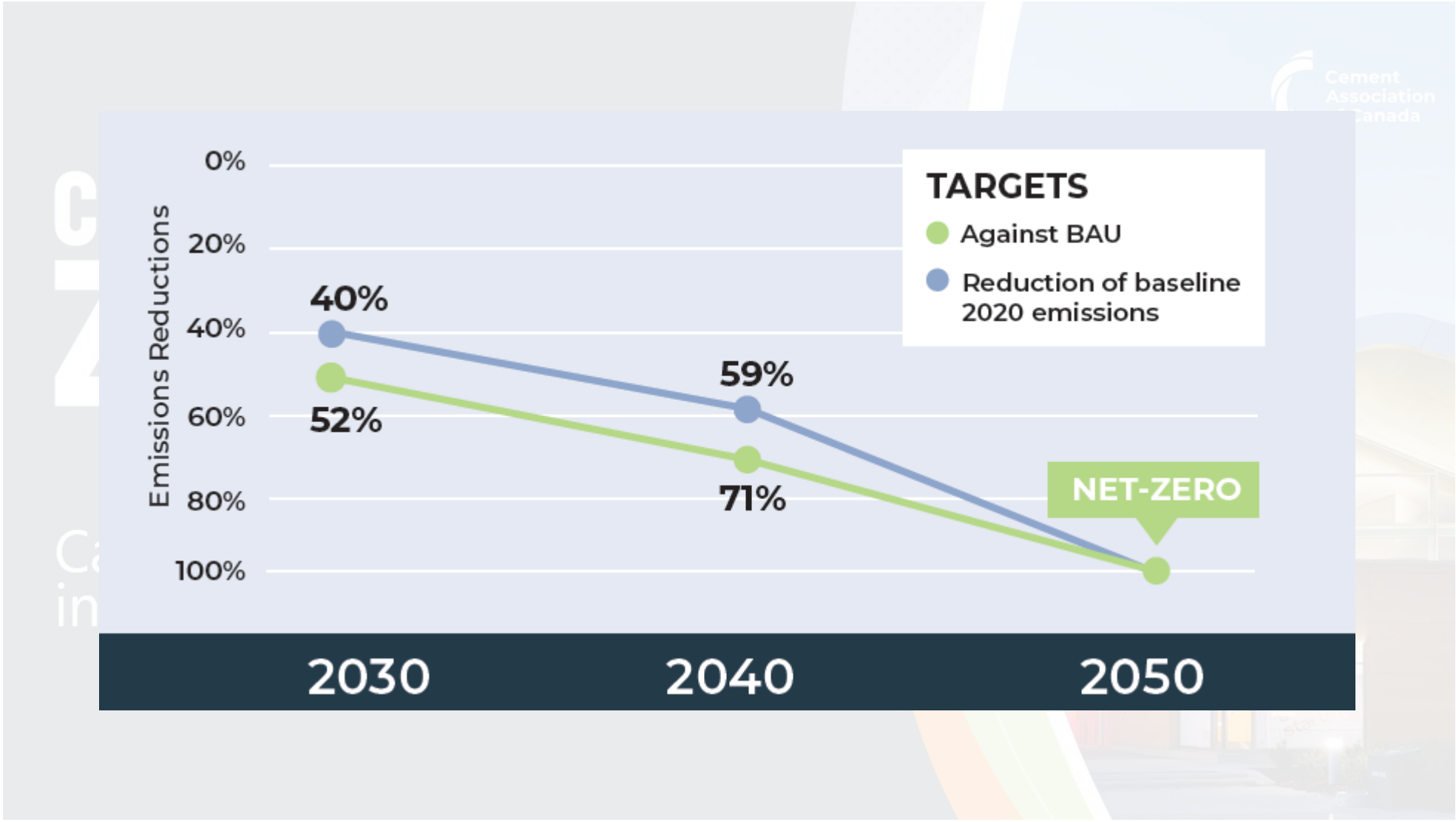
A MEMBER OF HOLCIM GROUP

CONCRETE ZERO

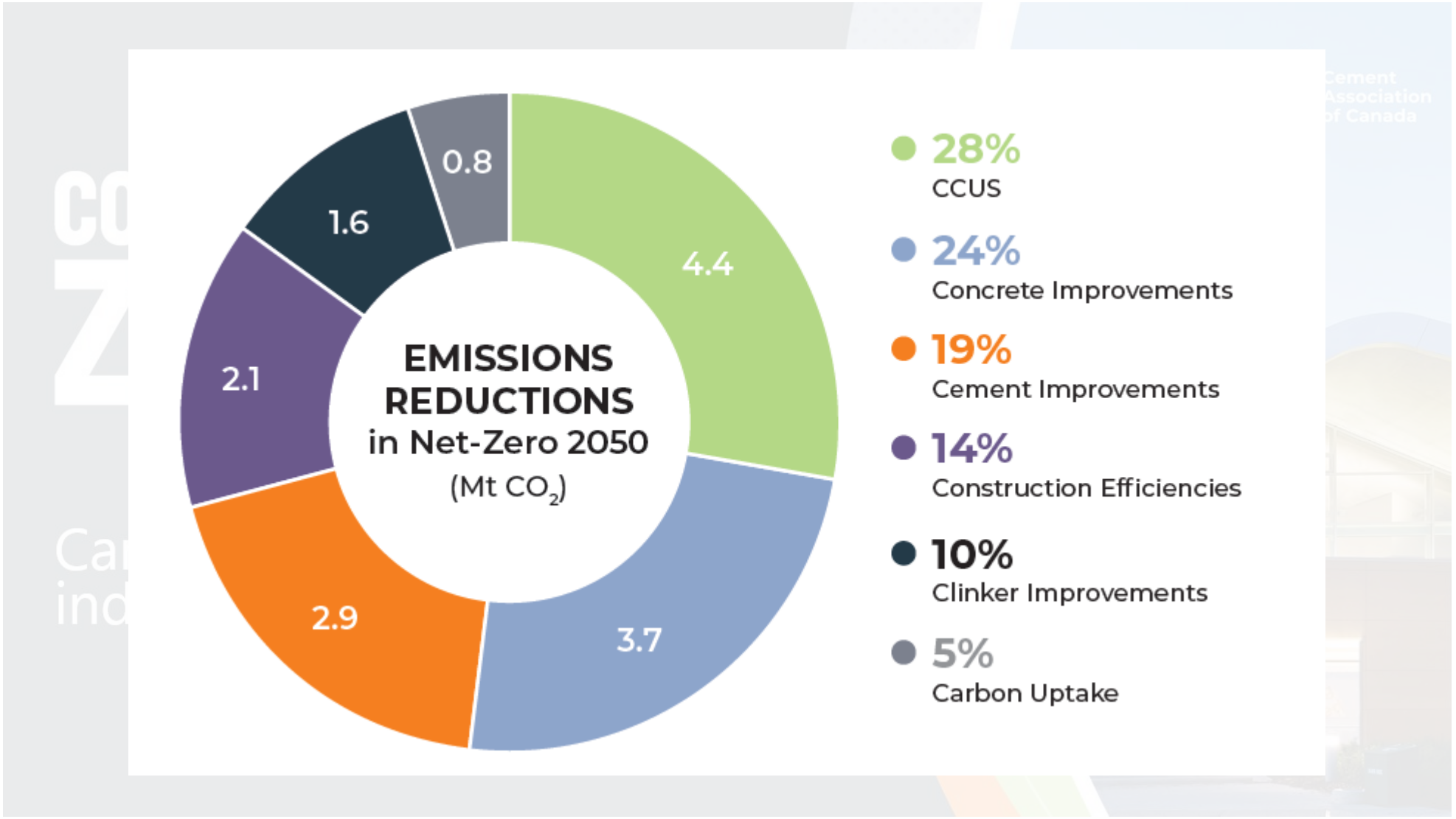
Canada's cement and concrete industry action plan to Net Zero

Cement Association of Canada

Industry Concrete Zero Roadmap



Industry Concrete Zero Roadmap



Policy Recommendations

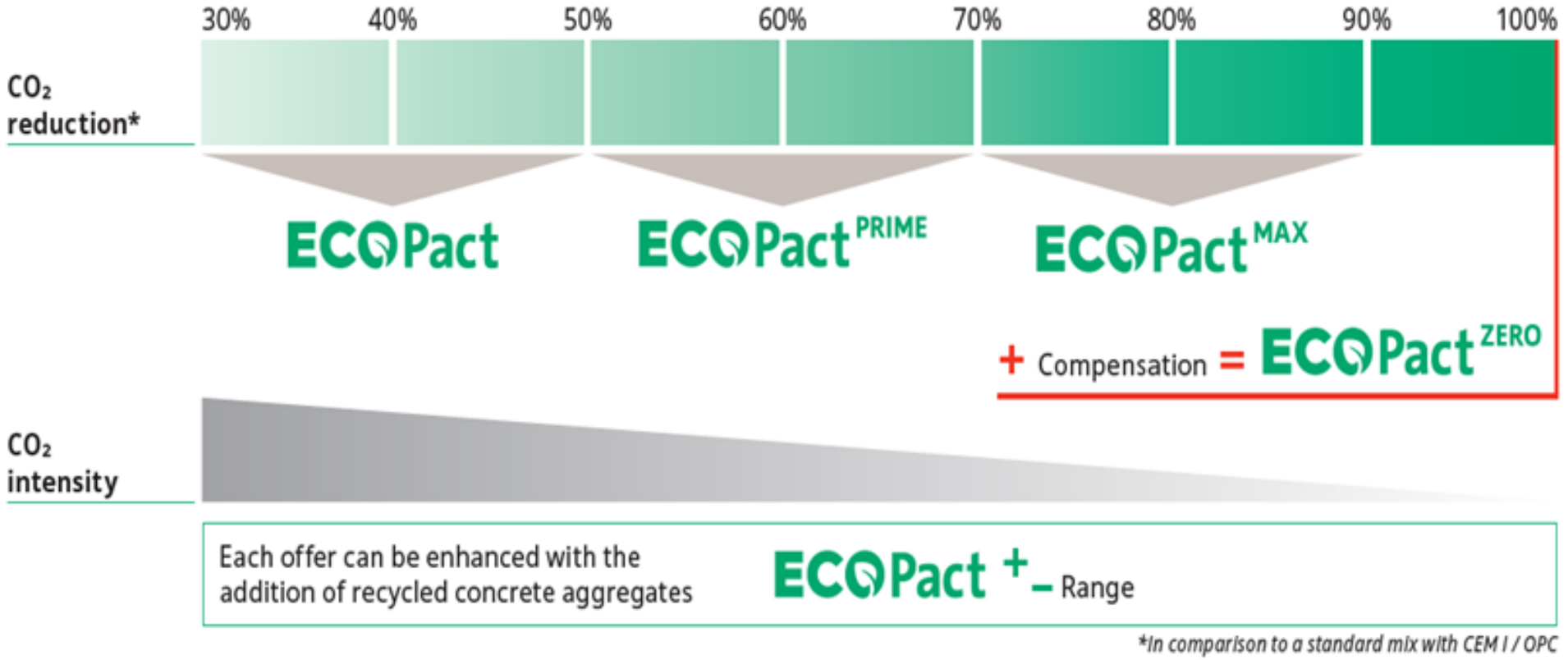
Material agnostic
- **Equitable treatment of structural materials**

Focus on performance outcomes
- **Functional equivalence**

Recognize improved structure resiliency

Recognize and promote local vs imported materials

Lafarge ECOPact Concrete



Lafarge ECOPact Concrete

- **Reductions achieved through**
  - **Use of GUL cement**
  - **Optimization of aggregate gradation**
  - **Use of NewCem SCM**
  - **Optimized use of concrete admixtures**
- **Costs**
  - **No cost implications or precautions for non ECOPact concrete**
    - **5 to 10% reduced carbon**
  - **5% cost increase for ECOPact**
- **Precautions**
  - **Higher ECOPact levels require additional curing**
  - **Schedule impacts due to slower strength gain may be able to be offset**
- **Future availability**
  - **Other SCMs are being developed**

A MEMBER OF
HOLCIM GROUP

Impact of Vancouver Building Bylaw on Embodied Carbon and Concrete

Vancouver

06.05.2024

Heidelberg Materials

“Industry Average” Environmental Product Declaration Baseline

Table 15. LCA Results 35 MPa Concrete without air (N)

	Unit	Baseline 35 MPa Concrete without air (N) GU 20 SCM	35 Mpa Concrete without air (N) GU	35 Mpa Concrete without air (N) GU 15 SCM	35 Mpa Concrete without air (N) GU 25 SCM	35 Mpa Concrete without air (N) GUL 15 SCM	35 Mpa Concrete without air (N) GUL 25 SCM	35 Mpa Concrete without air (N) GUL 40 SCM
Environmental impacts								
GWP	kg CO_2 eq.	293.75	345.52	306.69	280.81	285.01	261.67	226.66

BC Regional Industry Average Concrete for a given strength and exposure class is typically:

- Type GU Cement
- 20% SCM Use

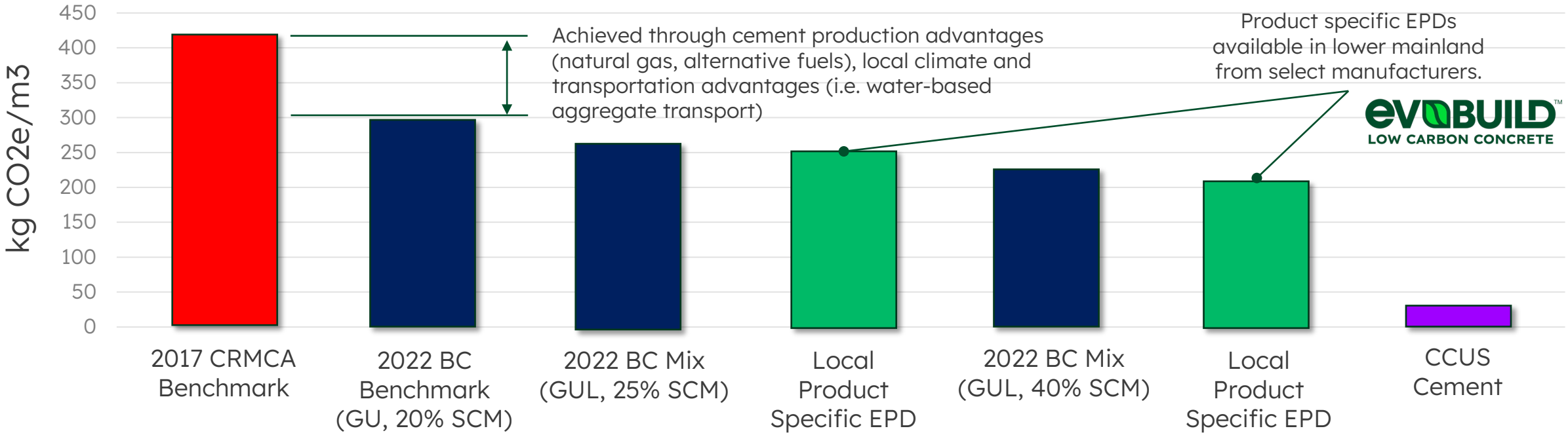
~10% reduction can be achieved:

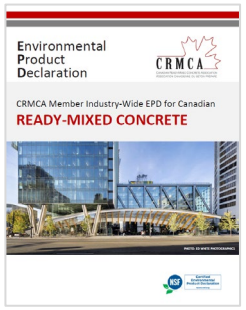
- Type GUL Cement (now standard in BC)
- Moderate SCM use increase (25%)

Enhanced reductions (~20%) can be achieved
→ Schedule and cost implications likely

https://concretebc.ca/wp-content/uploads/2022/10/810.CRMCA_EPD_BC.pdf

Example: 35 Mpa without Air (Class N) – i.e. Suspended Slab Application





Edmonton, Alberta

First large-scale plant in North America for carbon capture, use and storage in the cement industry, **scheduled for completion in 2026**. Gradual increase of carbon capture activities planned in capture to 1,000,000 tonnes CO2 reduction per annum.

EQUILIBRIUM

Structural Sustainability

Approaches to VBBL 2025

Tom Place

May 2024

Context

Half of embodied is structure

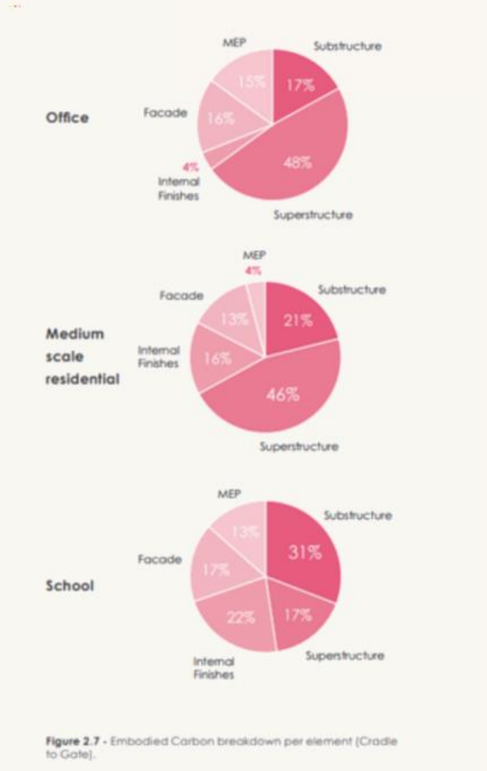
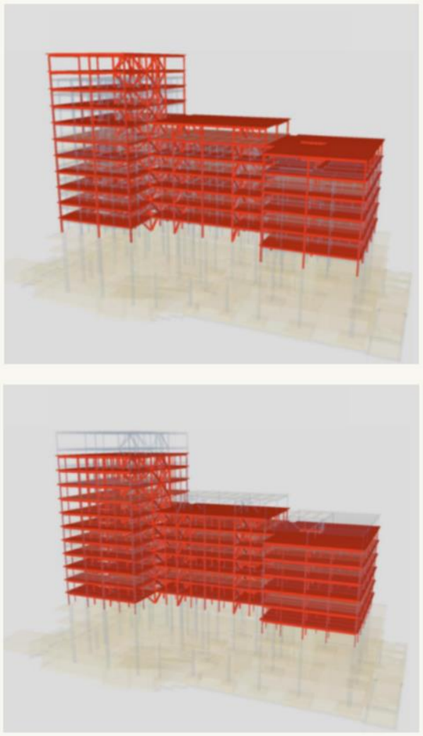
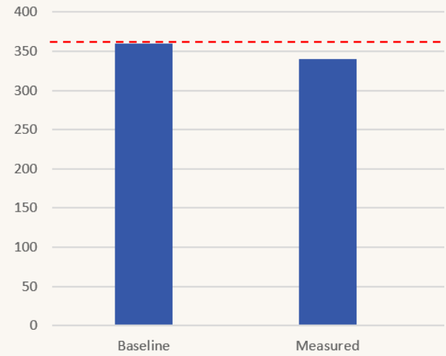


Figure 2.7 - Embodied Carbon breakdown per element (Cradle to Gate).

Route 1: Baseline Comparison



Route 2: Absolute Benchmark



Proposed targets are simple and achievable

Source: LETI Embodied Carbon Primer

Structural Design Strategies

Step 1 - Efficient Design

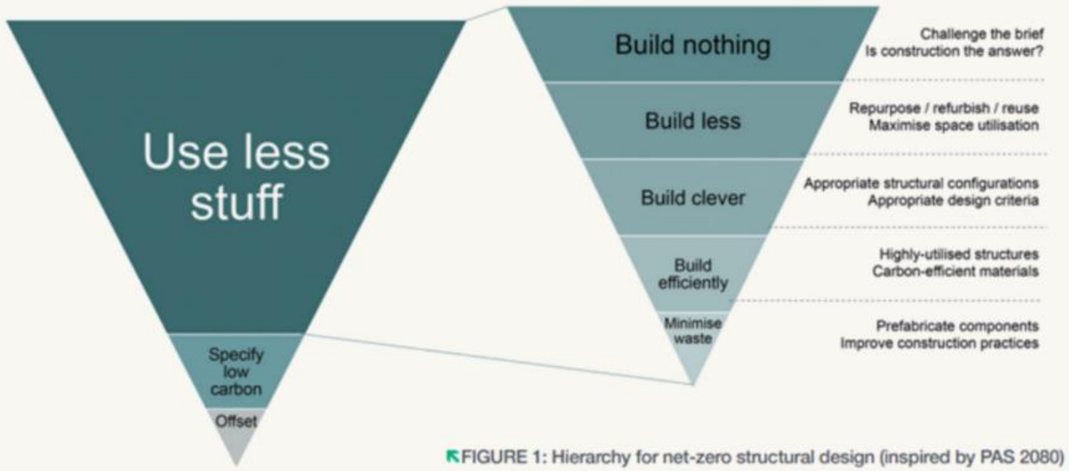


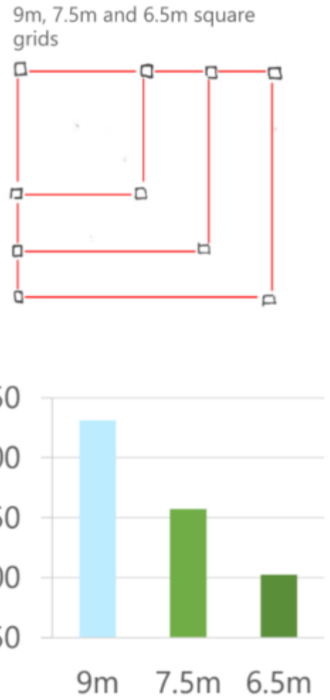
FIGURE 1: Hierarchy for net-zero structural design (inspired by PAS 2080)

- Refine the Structure
  - Shorten Spans
  - Remove Transfers
  - Change floor framing
  - Reduce basement volumes
- Challenge the brief
  - Reduce floor loading
  - Reduce parking
- Re-use what's there

Reduce material to save cost and carbon

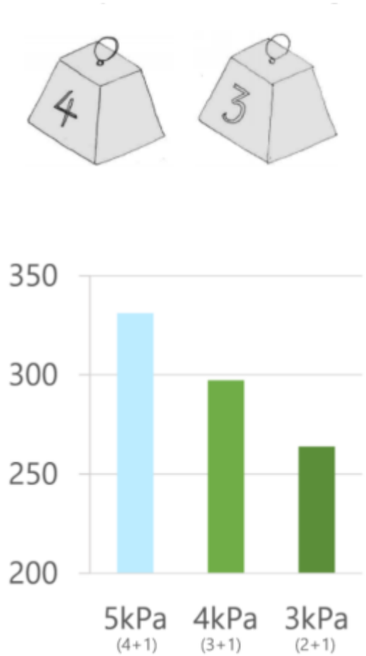
Source: IStructE "Putting the net zero hierarchy into practice"

Column Grid



20-40% Saving

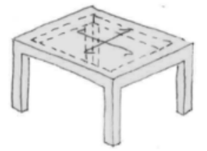
Imposed Loading



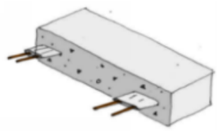
10-20% Saving

Structural Framing

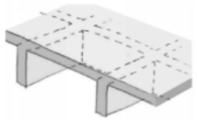
Concrete Flat Slab
400mm Flat Slab
700x700 RC columns (2% reinf)
250mm thick Cores and Shear Walls
C32/40 Concrete



Beam & Slab
230mm slab on
700 x 600 beams on grid



Post Tensioned Slab
260mm thick



Waffle Slab
400mm thk with 150mm
ribs @ 900mm c/c

20-40% Saving

Source: https://www.istructe.org/resources/case-study/embodied-carbon-structural-sensitivity-study/

Structural Design Strategies

Step 2 – Smart Specification

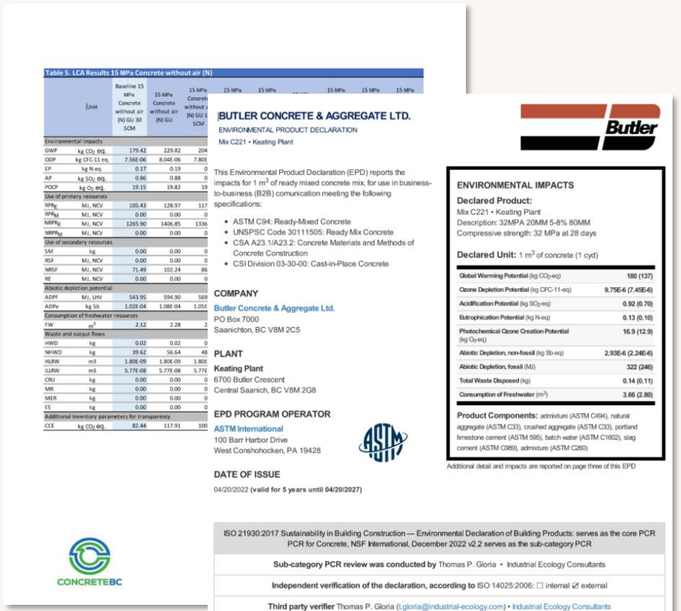


Table 5. LCA Results 15 MPa Concrete without air (N)

	Unit	Baseline 15 MPa Concrete without air (N) GU 30 SCM	15 MPa Concrete without air (N) GU	15 MPa Concrete without air (N) GU 5 SCM	15 MPa	15 MPa	15 MPa	15 MPa	15 MPa
Environmental impacts									
GWP	kg CO_2 eq.	179.42	229.82	204					
ODP	kg CFC-11 eq.	7.56E-06	8.04E-06	7.80E					
EP	kg N eq.	0.17	0.19	0					
AP	kg SO_2 eq.	0.86	0.88	0					
POCP	kg O_3 eq.	19.15	19.82	19					
Use of primary resources									
RPR_E	MJ, NCV	105.43	128.97	117					
RPR_M	MJ, NCV	0.00	0.00	0					
$NRPR_E$	MJ, NCV	1265.90	1406.85	1336					
$NRPR_M$	MJ, NCV	0.00	0.00	0					
Use of secondary resources									
SM	kg	0.00	0.00	0					
RSF	MJ, NCV	0.00	0.00	0					
NRSF	MJ, NCV	71.49	102.24	86					
NF	MJ, NCV	0.00	0.00	0					
Abiotic depletion potential									
ADPF	MJ, UHV	543.95	594.90	569					
ADPe	kg Sb	1.02E-04	1.08E-04	1.05E					
Consumption of freshwater resources									
FW	m^3	2.12	2.28	2					
Waste and output flows									
HWD	kg	0.02	0.02	0					
NHWD	kg	39.62	56.64	48					
HLRW	m3	1.80E-09	1.80E-09	1.80E					
ILLRW	m3	5.77E-08	5.77E-08	5.77E					
CRU	kg	0.00	0.00	0					
MR	kg	0.00	0.00	0					
MER	kg	0.00	0.00	0					
EE	kg	0.00	0.00	0					
Additional inventory parameters for transparency									
CCE	kg CO_2 eq.	82.44	117.91	100					

BUTLER CONCRETE & AGGREGATE LTD.

ENVIRONMENTAL PRODUCT DECLARATION

Mix C221 • Keating Plant

This Environmental Product Declaration (EPD) reports the impacts for 1 m^3 of ready mixed concrete mix, for use in business-to-business (B2B) comunication meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

COMPANY

Butler Concrete & Aggregate Ltd.
PO Box 7000
Saanichton, BC V8M 2C5

PLANT

Keating Plant
6700 Butler Crescent
Central Saanich, BC V8M 2G8

EPD PROGRAM OPERATOR

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428

DATE OF ISSUE

04/20/2022 **(valid for 5 years until 04/20/2027)**

ENVIRONMENTAL IMPACTS

Declared Product:
Mix C221 • Keating Plant
Description: 32MPA 20MM 5-8% 80MM
Compressive strength: 32 MPa at 28 days

Declared Unit: 1 m^3 of concrete (1 cyd)

Global Warming Potential (kg CO_2-eq)	**180 (137)**
Ozone Depletion Potential (kg CFC-11-eq)	**9.75E-6 (7.45E-6)**
Acidification Potential (kg SO_2-eq)	**0.92 (0.70)**
Eutrophication Potential (kg N-eq)	**0.13 (0.10)**
Photochemical Ozone Creation Potential (kg O_3-eq)	**16.9 (12.9)**
Abiotic Depletion, non-fossil (kg Sb-eq)	**2.93E-6 (2.24E-6)**
Abiotic Depletion, fossil (MJ)	**322 (246)**
Total Waste Disposed (kg)	**0.14 (0.11)**
Consumption of Freshwater (m^3)	**3.66 (2.80)**

Product Components: admixture (ASTM C494), natural aggregate (ASTM C33), crushed aggregate (ASTM C33), portland limestone cement (ASTM 595), batch water (ASTM C1602), slag cement (ASTM C989), admixture (ASTM C260)

Additional detail and impacts are reported on page three of this EPD

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products: serves as the core PCR
PCR for Concrete, NSF International, December 2022 v2.2 serves as the sub-category PCR

Sub-category PCR review was conducted by Thomas P. Gloria • Industrial Ecology Consultants

Independent verification of the declaration, according to ISO 14025:2006: ☐ internal ☑ external

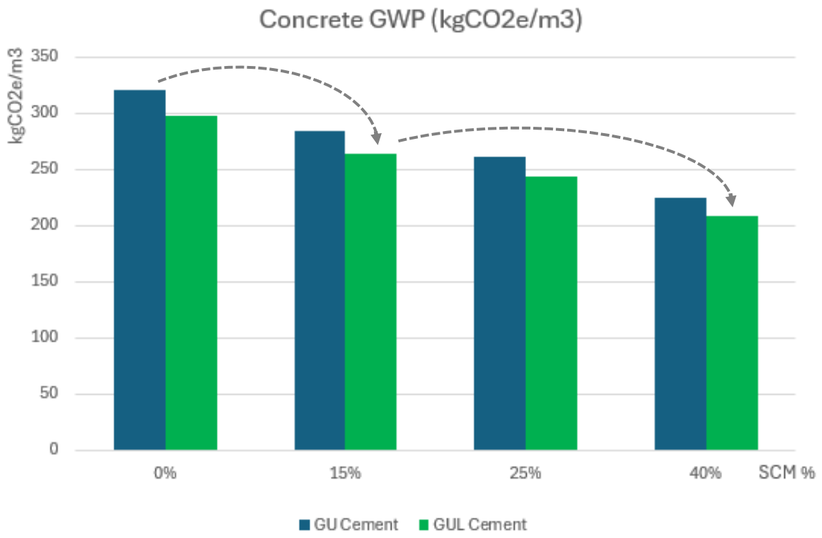
Third party verifier Thomas P. Gloria (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants

For additional explanatory material
Manufacture Representative: Travis Butler (tbutler@butlerco.ca)
Software Tool: CarbonCLARITY Suite, EPD Generator • Verification
LCA & EPD Developer: Climate Earth (support@climateearth.com)

- Concrete
  - GUL saves 5-15% at no cost or curing impact typ.
  - Set total carbon budgets, adjust mixes.
- Steel
  - Local supply of EAF steel exists.
- Timber
  - PNW supply & skills
  - Fast erection & pre-fabrication
  - Up to 18-storeys per BCBC 2024

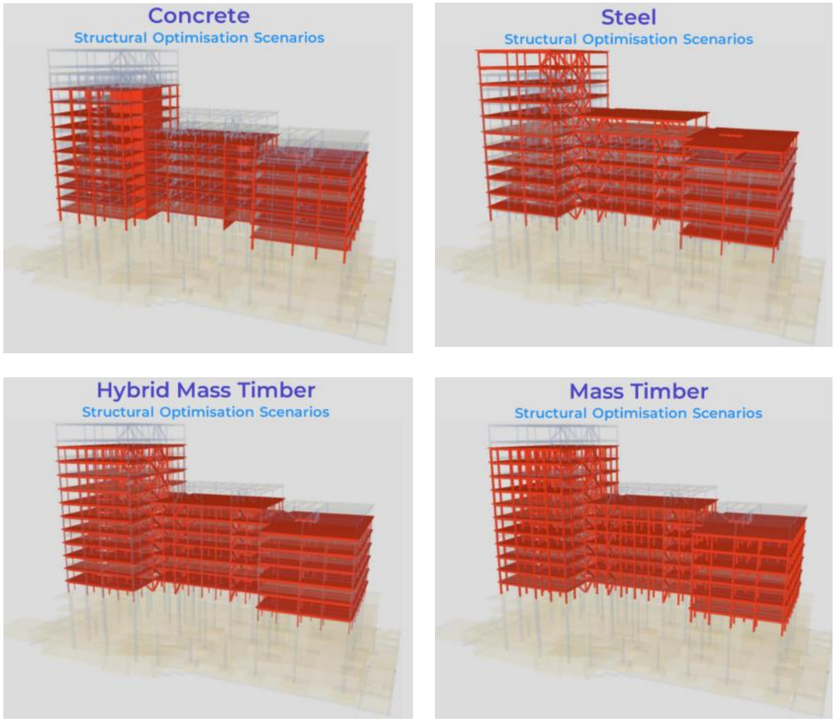
Source: https://concretebc.ca/wp-content/uploads/2022/10/810.CRMCA_EPD_BC.pdf

Concrete Specification



5-35% Saving

Material Choice



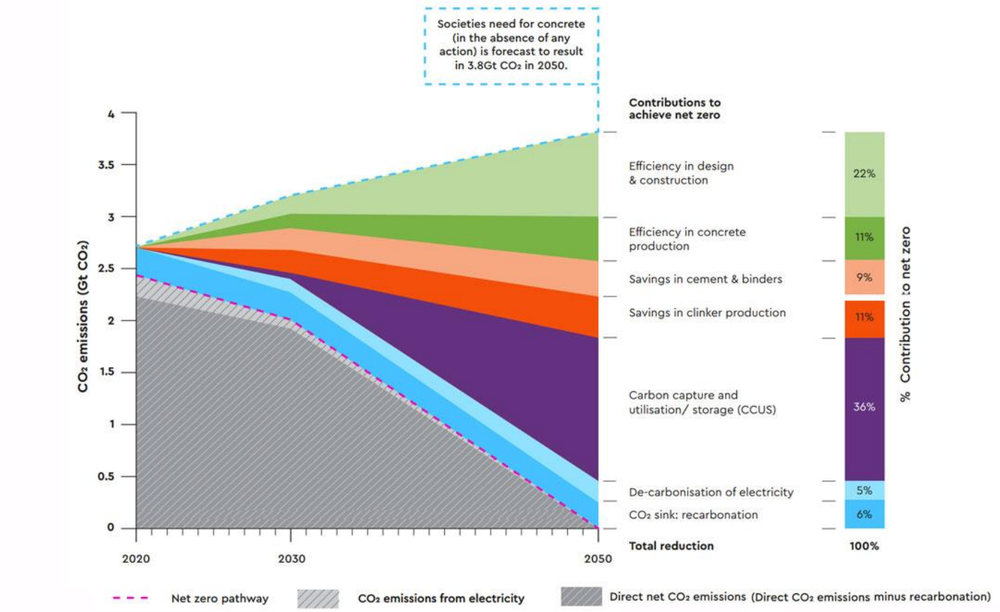
0-30% Saving

Source: https://concretebc.ca/wp-content/uploads/2022/10/810.CRMCA_EPD_BC.pdf

Source EQUILIBRIUM/ Priopta

Long Term View

Concrete Innovation

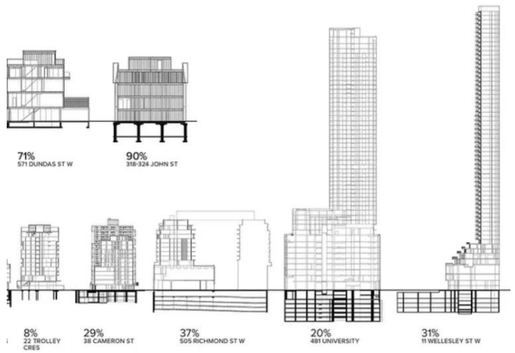


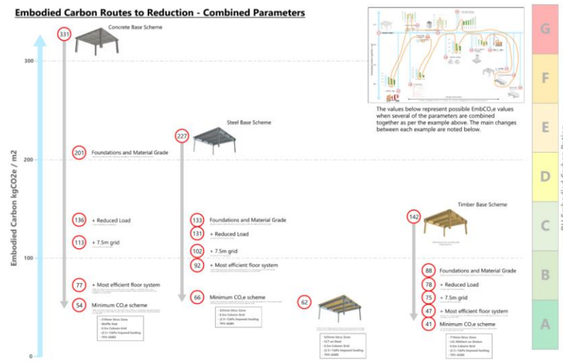
Source: https://gccassociation.org/

Building Upgrade & Re-use

Source:https://www.arup.com/projects/1-triton-square/

Design Efficiency





Source: https://www.istructe.org/resources/case-study/embodied-carbon-structural-sensitivity-study/

4th + Macdonald.

KITSILANO

5 storeys of residential woodframe over concrete retail at grade & 2 levels of underground parkade

99
RENTAL HOMES

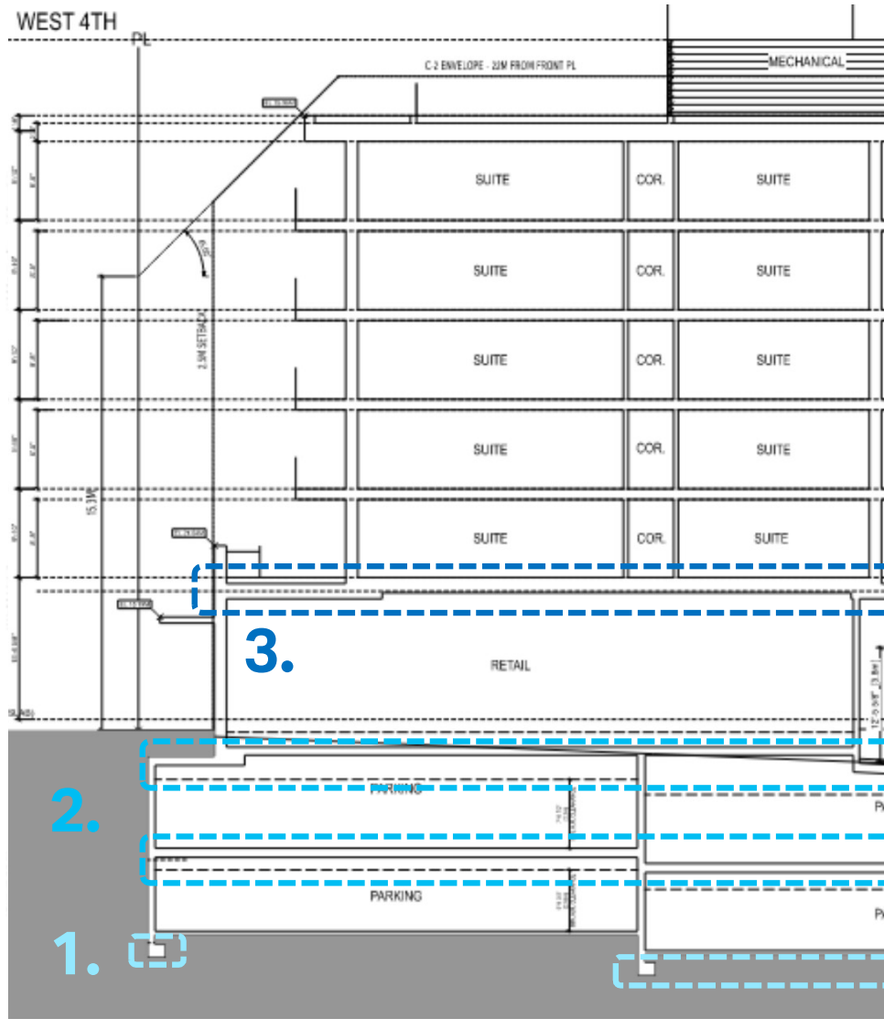
15K
NEW RETAIL SF

350 kgCO2e/m2

THIRD.SPACE

structure.

	Typical Option			Sustainable Option		
1.	**Foundations**			**Foundations**		
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**
	6'-6" x 6'-6" x 4'-0" R/W (10)-25M Each Way	20 MPa	46,854	6'-6" x 6'-6" x 2'-6" R/W (12)-25M Each Way & 20M@12" Stirrups - 56 day concrete mix design - SCM Content: 20% fly ash and 30% slag min	20 MPa	34,960
2.	**Parkade Suspended Slab**			**Parkade Suspended Slab**		
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**
	250 Flat Slab	35 MPa	198,997	200 Slab with 6'-0" x 6'-0" x 16" Column Capitals - SCM Content: 20% fly ash min	35 MPa	172,162
3.	**L2 Transfer Slab**			**L2 Transfer Slab**		
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**
	460 Flat Slab	40 MPa	338,319	250 Slab with 900W x 700 DP Transfer Beams - SCM Content: 20% fly ash and 30% slag min	35 MPa	271,809



THIRD.SPACE

structure.

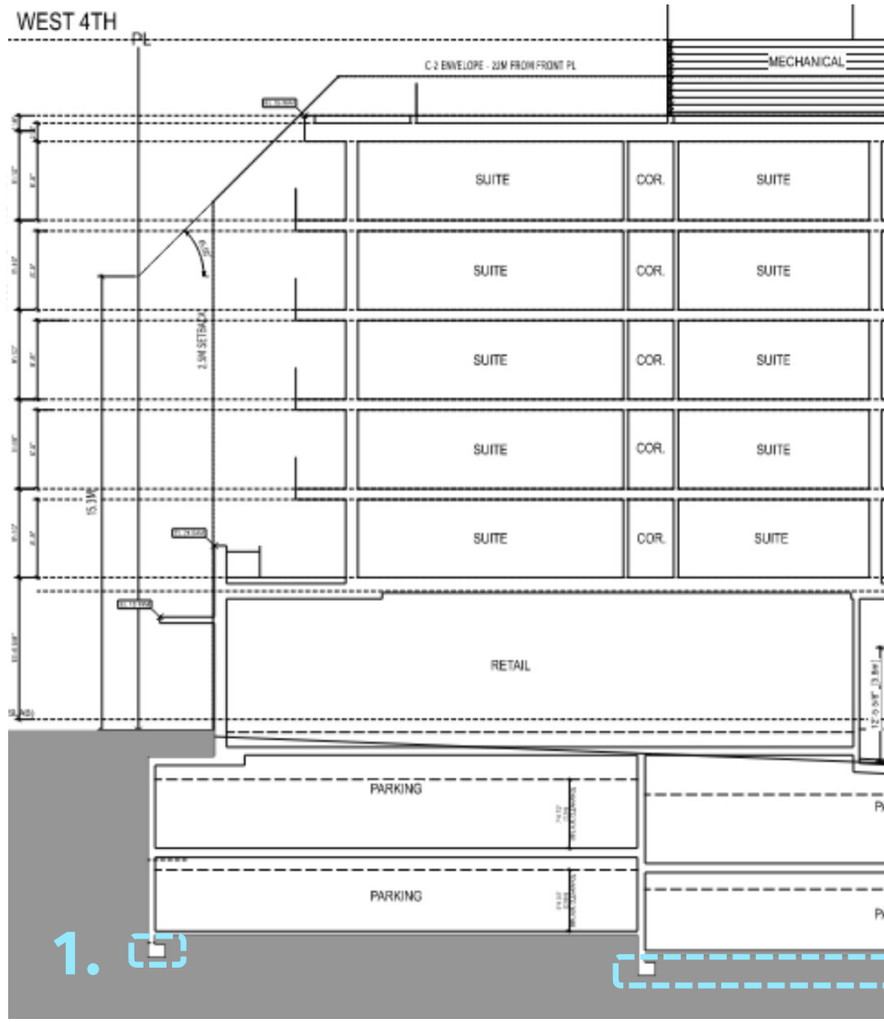
1.

Typical Option		
Foundations		
Element	**f'c**	**GWP (kgCO2e)**
6'-6" x 6'-6" x 4'-0" R/W (10)-25M Each Way	20 MPa	46,854

Sustainable Option		
Foundations		
Element	**f'c**	**GWP (kgCO2e)**
6'-6" x 6'-6" x 2'-6" R/W (12)-25M Each Way & 20M@12" Stirrups	20 MPa	34,960

- 56 day concrete mix design
- SCM Content: 20% fly ash and 30% slag min

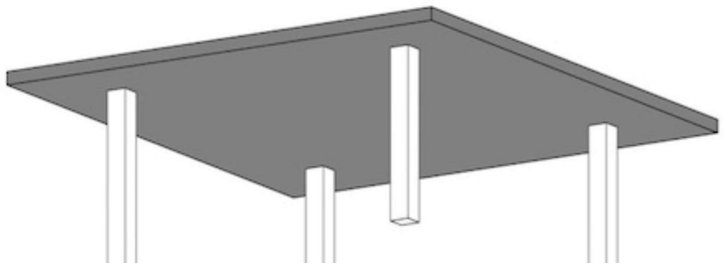
Figure 3 - Typical Pad Footing Construction



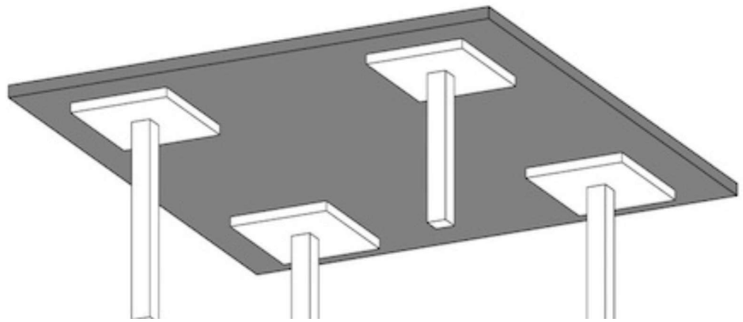
structure.

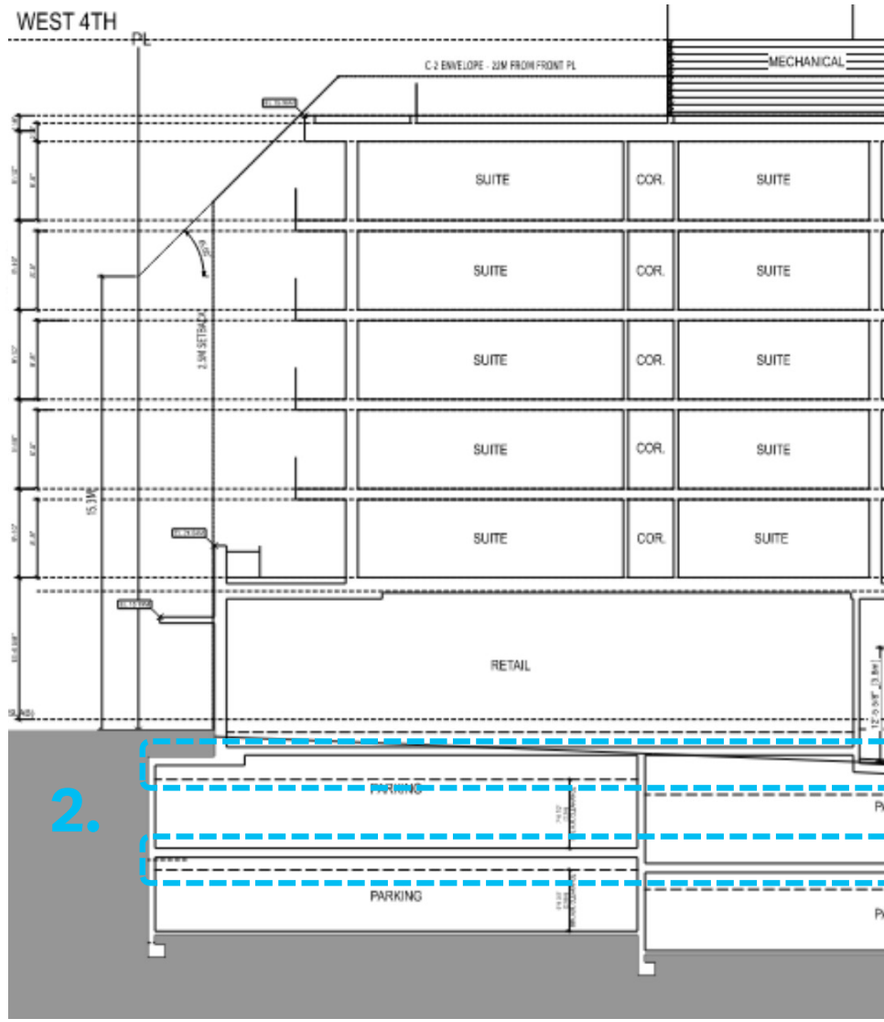
2.

Parkade Suspended Slab		
Element	**f'c**	**GWP (kgCO2e)**
250 Flat Slab	35 MPa	198,997



Parkade Suspended Slab		
Element	**f'c**	**GWP (kgCO2e)**
200 Slab with 6'-0" x 6'-0" x 16" Column Capitals - SCM Content: 20% fly ash min	35 MPa	172,162



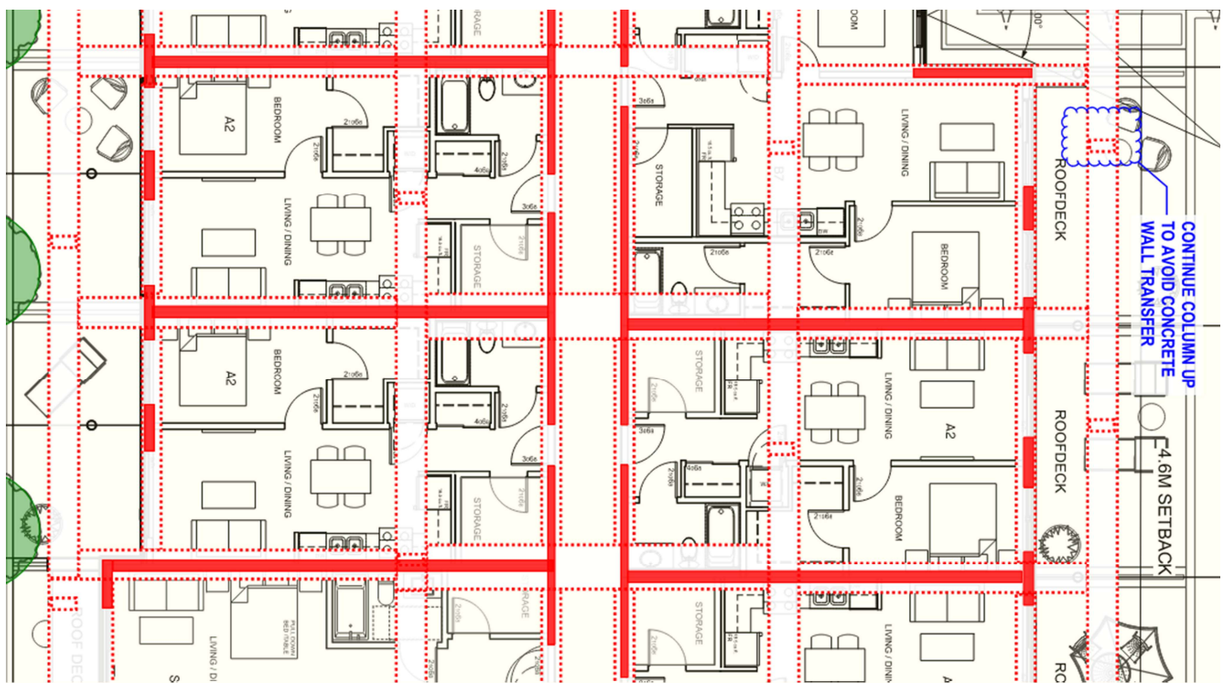


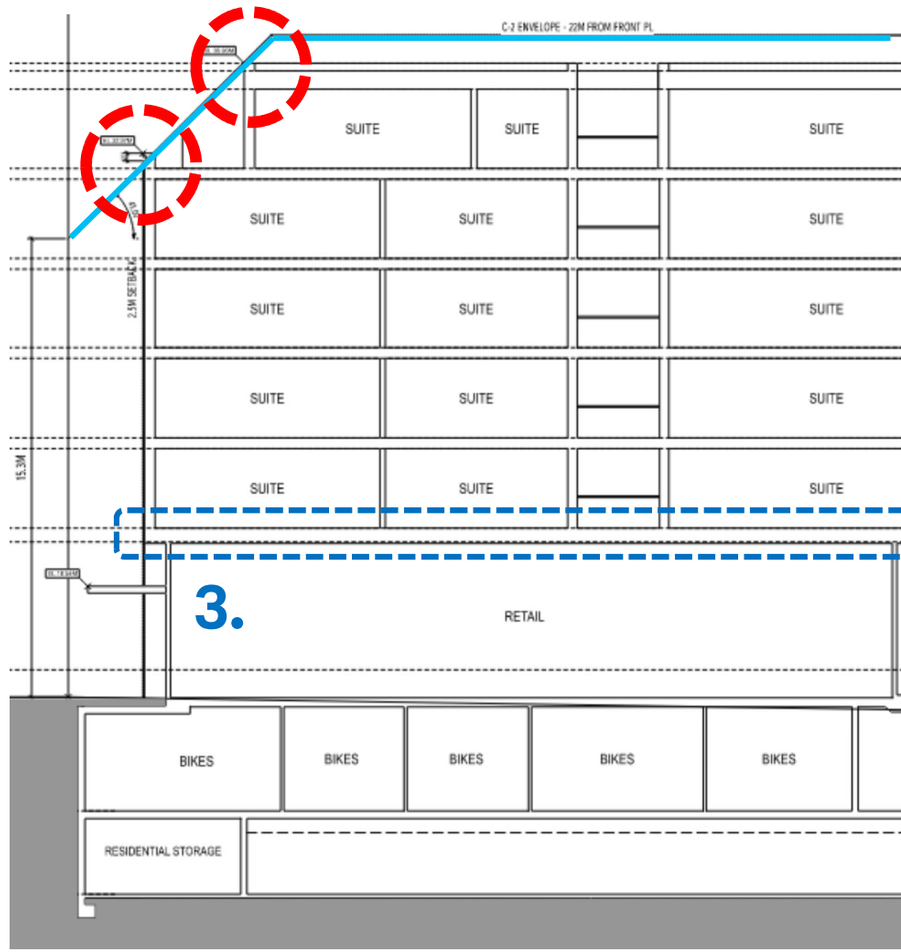
structure.

3.

L2 Transfer Slab		
Element	**f'c**	**GWP (kgCO2e)**
460 Flat Slab	40 MPa	338,319

L2 Transfer Slab		
Element	**f'c**	**GWP (kgCO2e)**
250 Slab with 900W x 700 DP Transfer Beams - SCM Content: 20% fly ash and 30% slag min	35 MPa	271,809





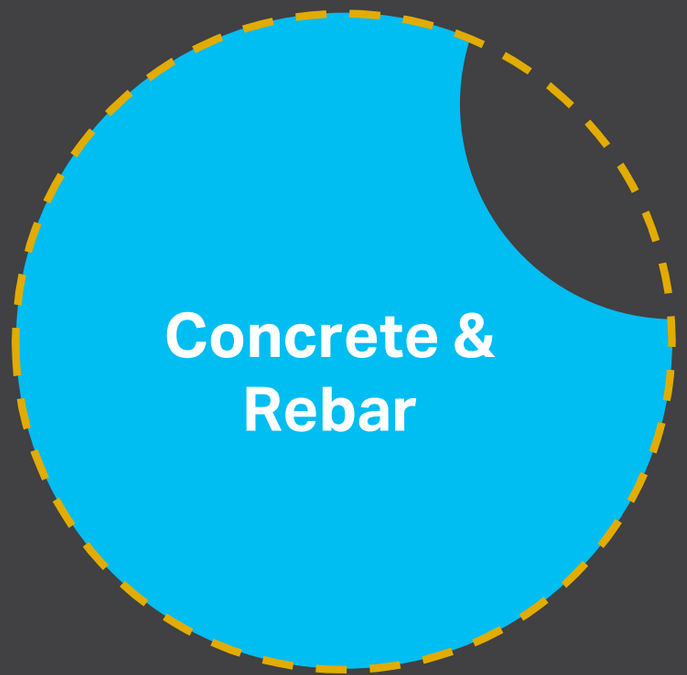
THIRD.SPACE

How much does it cost?

	Typical Option			Sustainable Option				
1.	**Foundations**			**Foundations**			-$30,000	-12,000kgCO2e
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**		
	6'-6" x 6'-6" x 4'-0" R/W (10)-25M Each Way	20 MPa	46,854	6'-6" x 6'-6" x 2'-6" R/W (12)-25M Each Way & 20M@12" Stirrups - 56 day concrete mix design - SCM Content: 20% fly ash and 30% slag min	20 MPa	34,960		
2.	**Parkade Suspended Slab**			**Parkade Suspended Slab**			-$5,000	-26,000kgCO2e
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**		
	250 Flat Slab	35 MPa	198,997	200 Slab with 6'-0" x 6'-0" x 16" Column Capitals - SCM Content: 20% fly ash min	35 MPa	172,162		
3.	**L2 Transfer Slab**			**L2 Transfer Slab**			-$30,000	-18,000kgCO2e
	Element	**f'c**	**GWP (kgCO2e)**	**Element**	**f'c**	**GWP (kgCO2e)**		
	~~460 Flat Slab~~ 400mm	40 MPa	338,319	~~250 Slab~~ with 900W x 700 DP Transfer Beams - SCM Content: 20% fly ash and 30% slag min	35 MPa	271,809	**-$65,000**	**-56,000kgCO2e**

THIRD.SPACE

Impact.

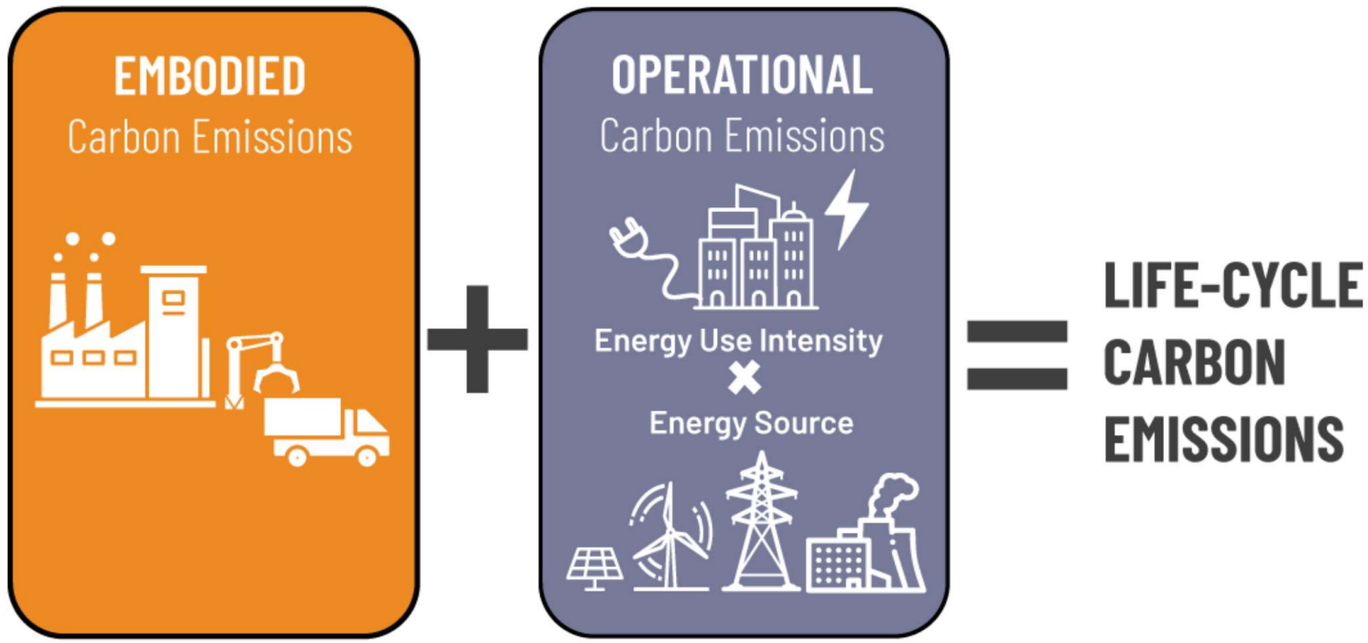


131,000 kgCO2e reduction (~9%)

- Concrete volume reductions
- Portland Limestone Cement (GUL)
- Longer cure time mixes where appropriate

-$65,000

whole life carbon...



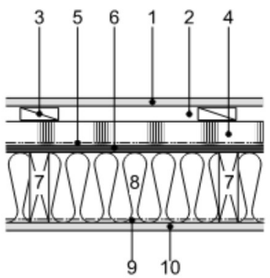
A building's carbon footprint over its lifespan is the sum of its embodied plus operational emissions.

Adapted from Magwood et al. 2021.

whole life carbon...

	EUI	TEDI	GHGI
CoV Minimums	**111.7**	**24.1**	**3**
Current Design Roof R-30; Walls R-15	105.6	14.2	1.16

EXTERIOR WALL W/ FIBRE-CEMENT CLADDING



1. 15.9mm (5/8")FIBRE-CEMENT SHIPLAP SIDING - PREPAINTED
2. MIN. 1" AIR SPACE
3. 1"x 3" TREATED PLYWOOD VERTICAL STRAPPING @ 400MM (16") O.C
4. 50.8mm (2") R-8.4 SEMI-RIGID INSULATION
5. BREATHABLE WEATHER PROTECTION MEMBRANE (M.B.)
6. 12.7mm (1/2") EXT. FIR PLYWOOD SHEATHING
7. 2x6 K.D. WOOD STUDS @ 400mm (16") O.C. (SEE STRUC. DWGS.)
7. 139.7mm (5 1/2") R-21 FIBERGLASS BATT INSULATION
8. 6 MIL POLY VAPOUR/AIR BARRIER
9. 1 LAYER OF 15.9mm (5/8") TYPE-X G.W.B.

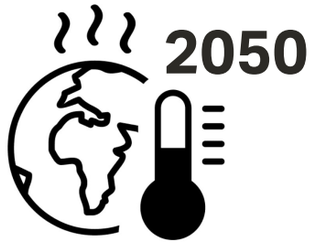
EXTERIOR CONCRETE WALL PAINTED

whole life carbon...

	EUI	TEDI	GHGI	Embodied	Operational
CoV Minimums	**111.7**	**24.1**	**3**		
Current Design Roof R-30; Walls R-15	105.6	14.2	1.16		8,917 kgCO2e/yr
Roof R-20	106.0	15.1	1.17	-7,000 kgCO2e	
Walls R-12 effective **(no exterior insulation)**	106.0	15.4	1.17	-23,000 kgCO2e	
Wall R-12 + Roof R-20	106.3	16.3	1.17		8,993 kgCO2e/yr
				-30,000 kgCO2e	+76 kgCO2e/yr
					....395 years

THIRD.SPACE

whole life carbon...



Cost Savings
~$250,000

	EUI	TEDI	GHGI
CoV Minimums	**111.7**	**24.1**	**3**
Current Design Roof R-30; Walls R-15	105.6	14.2	1.16
Wall R-12 + Roof R-20	106.3	16.3	1.17

Embodied	Operational
~30,000 kgCO2e	+76 kgCO2e/yr
	....395 years

THIRD.SPACE

whole life carbon...

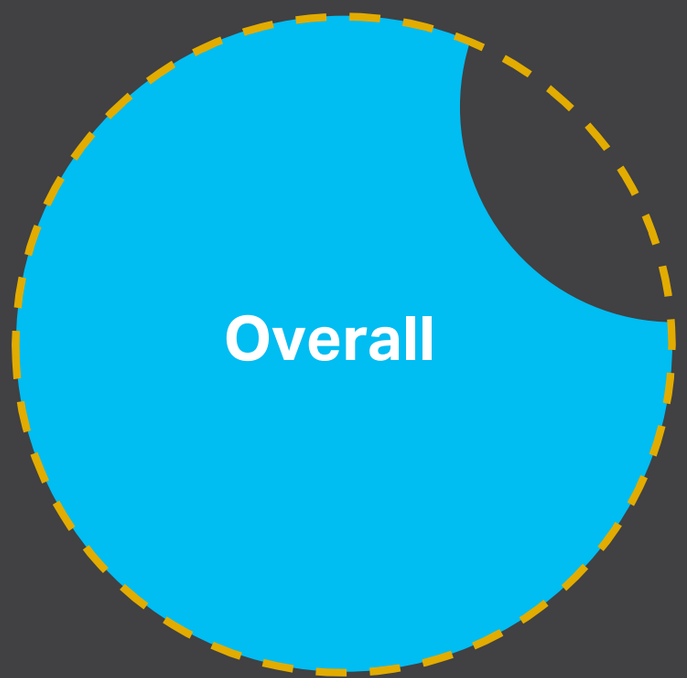
Cost Savings
~$250,000

	EUI	TEDI	GHGI
CoV Minimums	**111.7**	**24.1**	**3**
Current Design Roof R-30; Walls R-15	105.6	14.2	1.16
Wall R-12 + Roof R-20	106.3	16.3	1.17

Embodied	Operational
~30,000 kgCO2e	+76 kgCO2e/yr
	....395 years

THIRD.SPACE

Impact.



320 kgCO2e/m2 (~9%)

- Concrete volume reductions
- Concrete Specs (GUL & Mix designs)
- Insulation reductions