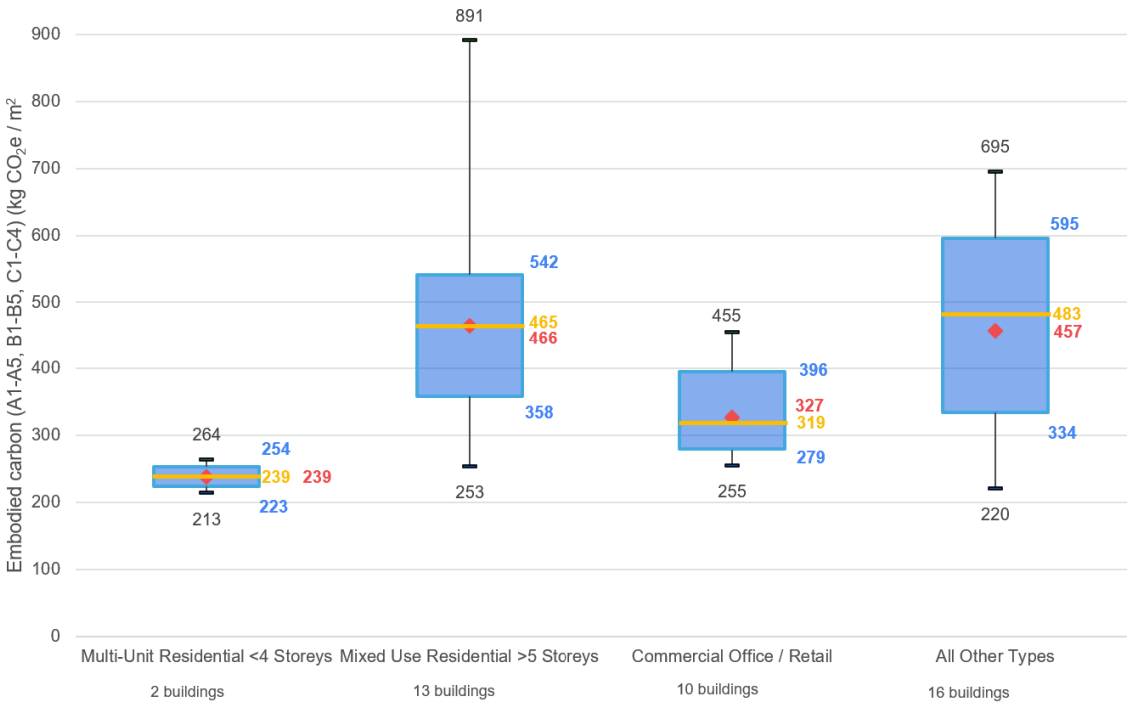
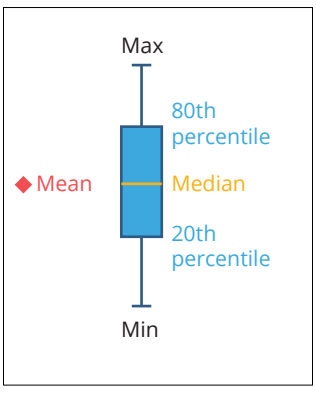
TAF TORONTO MANTLE DEVELOPMENTS UNIVERSITY OF TORONTO JOHN H. DANIELS FACULTY OF ARCHITECTURE, LANDSCAPE, AND DESIGN

2022

Part-3 Building Self-Reported Embodied Carbon

The below results are the first attempt to collect and compare embodied carbon results as calculated using whole building life cycle assessments (WBLCA) for Part-3 buildings in Ontario. We received results for 41 separate buildings. The results are shown below and will be used to inform future policy recommendations for the City of Toronto and other governments. Note there is some 'noise' in the results due to variations in methodology, scope of assessment, and tools used by the teams who calculated these values for each building. Nevertheless, these results are an important first step in understanding embodied carbon results in the City of Toronto and other Ontario municipalities.





Key Takeaways

1. Embodied carbon assessments are being undertaken across Ontario. Received results for 41 projects from 16 different respondents.
2. Projects predominantly used either One Click LCA or Athena software. The results of these tools seems to be relatively consistent (average intensity of 398* vs 434, respectively).
3. Embodied carbon intensities increase with building height due to increased materials per area and greater subsurface works.
4. Buildings with timber structures seem to have lower embodied carbon (~16% lower). Including sequestration makes this difference significant (~59% lower).
5. 'Upfront carbon' (A1-A5) also accounts for the vast majority of a project's total embodied carbon, on average ~90% of the data set.
6. Methodology differences make high quality comparisons between projects difficult. Any future policy should provide clear guidance for required life cycle phases, objects of assessment, material quantity data sources, and treatment of carbon sequestration.
7. We have found that significant carbon savings are immediately available to projects in their design stage. For example, working with one City of Toronto project, three material substitutions were approved (lower carbon concrete, lower impact XPS insulation, and lower impact concrete sealant) which led to a 26% reduction in total embodied emissions and over 800 tonnes of CO2e avoided!

**all values are embodied carbon (global warming potential) intensity, life cycle phases A1-A5, B1-B5, C1-C4, in units of kg CO2e/m2*

You can see the full report here.

Want to stay connected?
Sign up for updates and invites to engagement activities

Embodied carbon benchmarks for Part 3 buildings in the Greater Toronto-Hamilton Area

SURVEY FINDINGS

February 2022

NOTE: The following is not an official opinion/position of the City of Toronto, but will be used to inform policy considerations by the City.

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Project Overview

This project is the first initiative to collect and compare whole building life cycle assessment (WBLCA) results – also called embodied carbon assessments – for Part-3 buildings in Ontario.

Part-3 buildings can typically be thought of as buildings other than homes with only a handful of families, like single family or duplex. Part-3 buildings include commercial, industrial, institutional, larger multi-unit housing (typically more than five units), etc.

The project team is also working with two City of Toronto projects currently under design to quantify and reduce their embodied carbon. Lessons will be widely shared.

These slides represent our first public-facing summary to date.

Survey 1 - Overview

Focused on overall familiarity with LCA and/or embodied carbon.

Asked about barriers to performing LCA/embodied carbon analysis.

Sought information about the scope of the analysis.

Sought information about how the assessments were carried out including:

- what LCA software was used?
- what stage of the project was assessment done at?
- what kind of environmental data and/or sources was used?
- was carbon sequestration or carbonation accounted for?

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Survey 1 - Key Takeaways

1. Voluntary embodied carbon assessments are being done in the GTHA.
2. Data sources used range of from industry-average EPDs to product-specific EPDs to generic software/database entries.
3. LCA analysis is being done throughout design and construction processes - including schematic, design development, construction documents, and post-occupancy.
4. The market can support this type of analysis, evident by the number of expert respondents or familiar with tools.
5. Methodology differences make high quality comparisons between projects difficult. Any future policy should provide clear guidance for required life cycle phases, objects of assessment, material quantity data sources, and treatment of carbon sequestration.
6. Most common barrier to broader uptake is “not sure where to begin”.

Survey 1 - Example Question

18. What tools or software do you typically use to conduct your embodied carbon assessments? *

Check all that apply.

- [ ] Athena Impact Estimator for Buildings
- [ ] One Click LCA
- [ ] Embodied Carbon in Construction Calculator (EC3)
- [ ] Tally
- [ ] Excel / manual calculations
- [ ] SimaPro
- [ ] openLCA
- [ ] Unsure

Other: [ ] _____

19. Please describe any difficulties you faced when using any of the tools you selected in the previous question. Be sure to mention which tool you are referring to in your response. If you did not face any difficulties, please leave this answer blank.

_____

_____

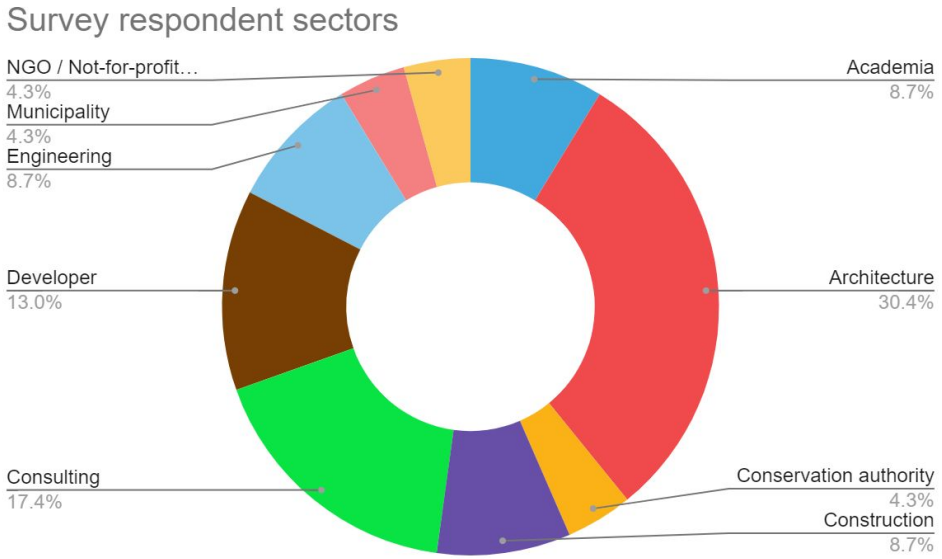
Survey 1 - Finding

24 respondents in total

Responses were submitted between September 29, 2021 - November 1, 2021

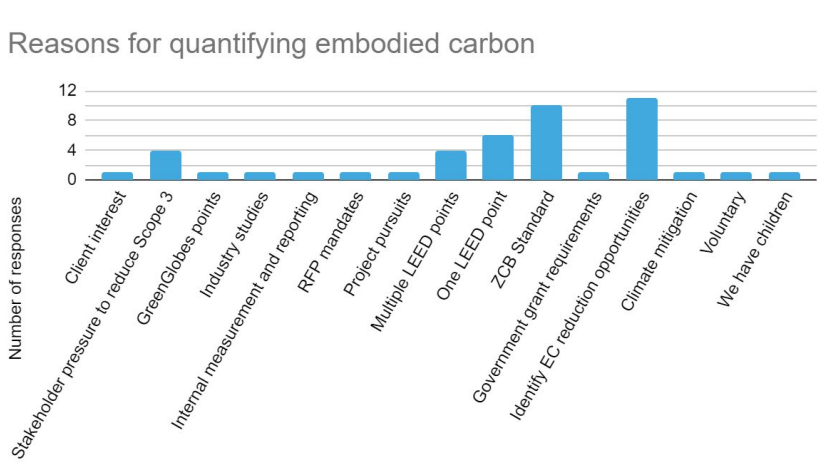
Roughly 60% of respondents were submitted by:

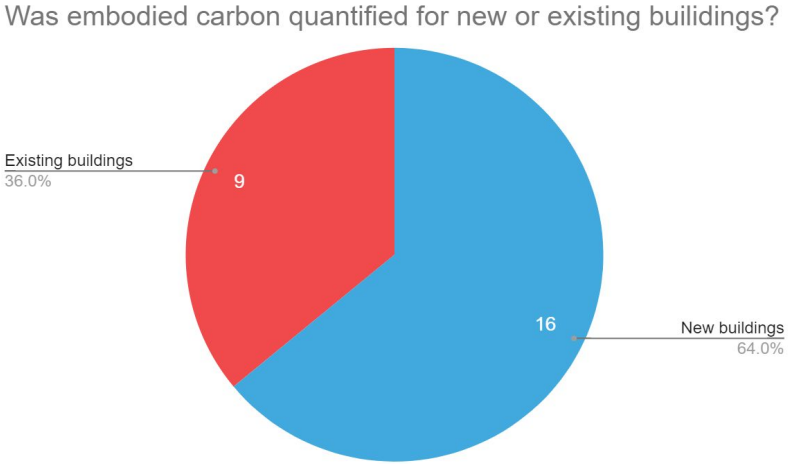
- Architecture firms
- Consulting firms
- Developers



Survey 1 - Reasons for quantifying embodied carbon

1. Identifying embodied carbon reduction opportunities
2. ZCB standard
3. LEED points
4. Stakeholder pressure (owner, investor, builder, etc.) to reduce Scope 3 emissions



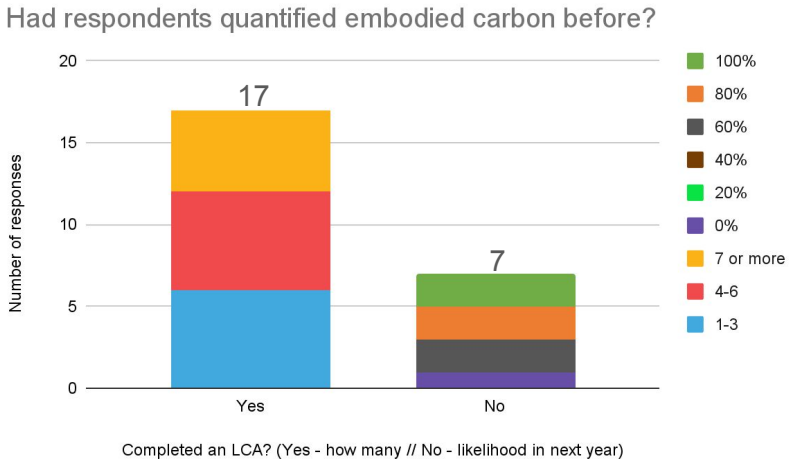


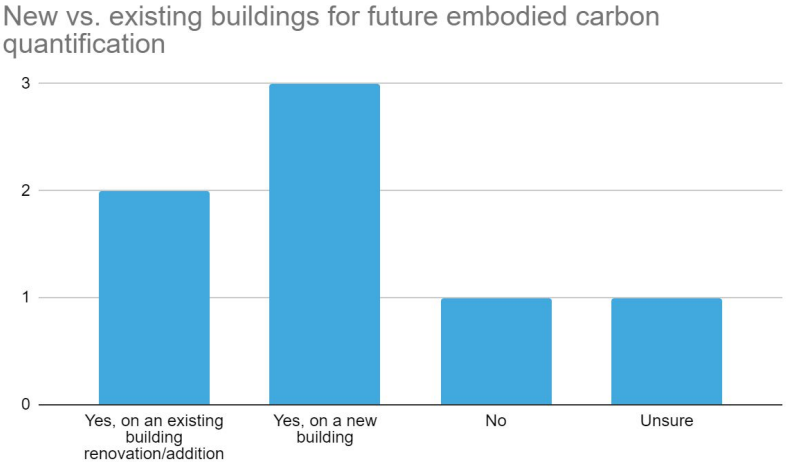
Most respondents had performed multiple analysis

Most respondents have performed multiple assessments
Keen interest in future embodied carbon quantification from those who haven't yet (see "No" column, green, orange, and grey segments)

Interest in quantifying embodied carbon by conducting LCAs is growing

Embodied carbon quantification should grow in the next year, aligning with new version of TGS



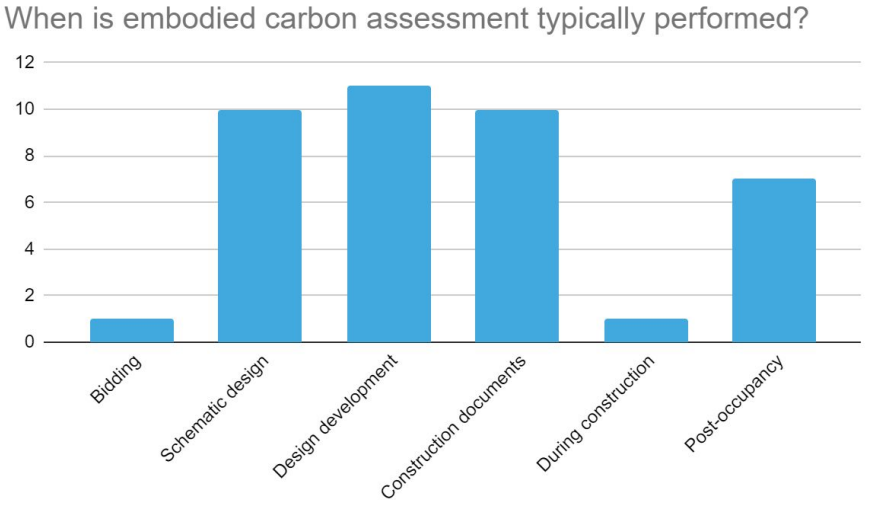


Project phase

Most assessments during design development

Nearly as many in schematic and construction documents.

Fewer but still a sizable amount done post-occupancy (when no reductions are possible)



Life-cycle phase

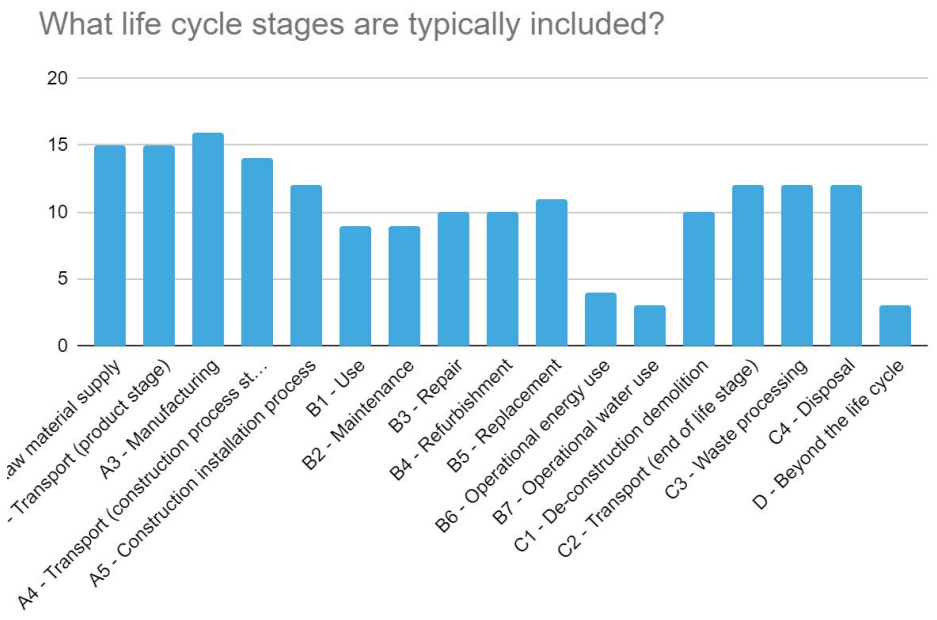
A range of life cycle phases were selected, therefore comparison between results is not straightforward

Only 3 respondents selected the same phases: A1-A5, B1-B5, C1-C4

2 respondents selected upfront carbon only: A1-A5

Another 2 respondents selected A1-A4, B2-B5, C2-C4, D

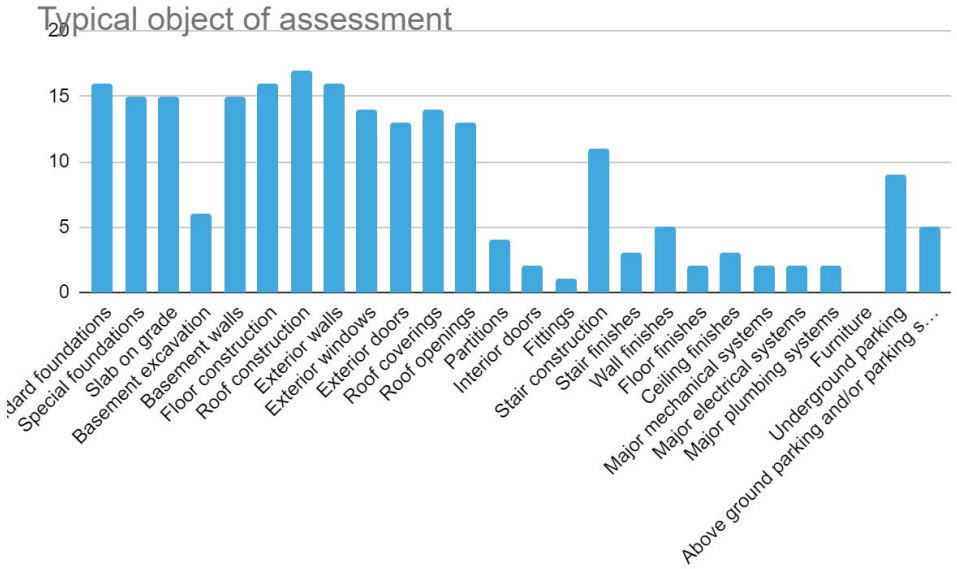
All other respondents chose a unique combination of phases



Object of assessment

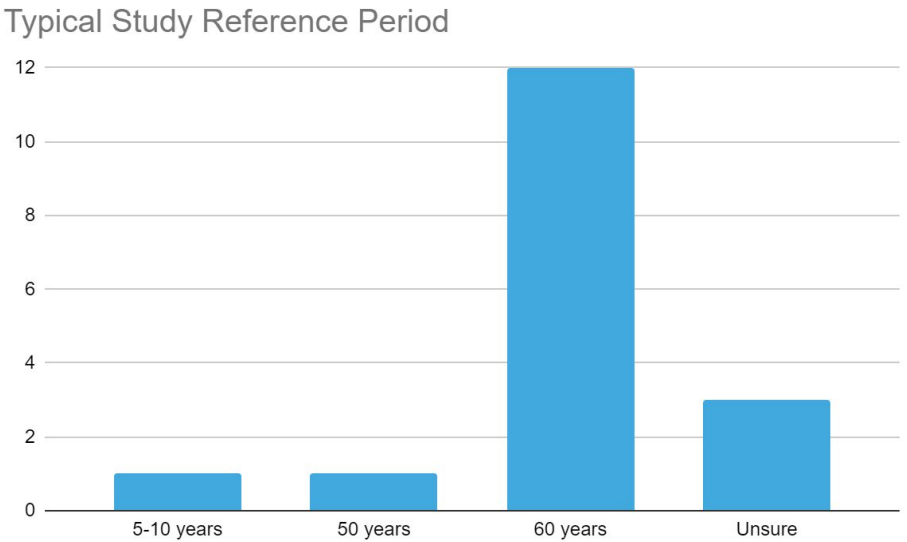
A range of object of assessment.

Some selected things that are not part of the LEED or CaGBC scope like basement excavation, mechanical, electrical, plumbing, partitions, etc.



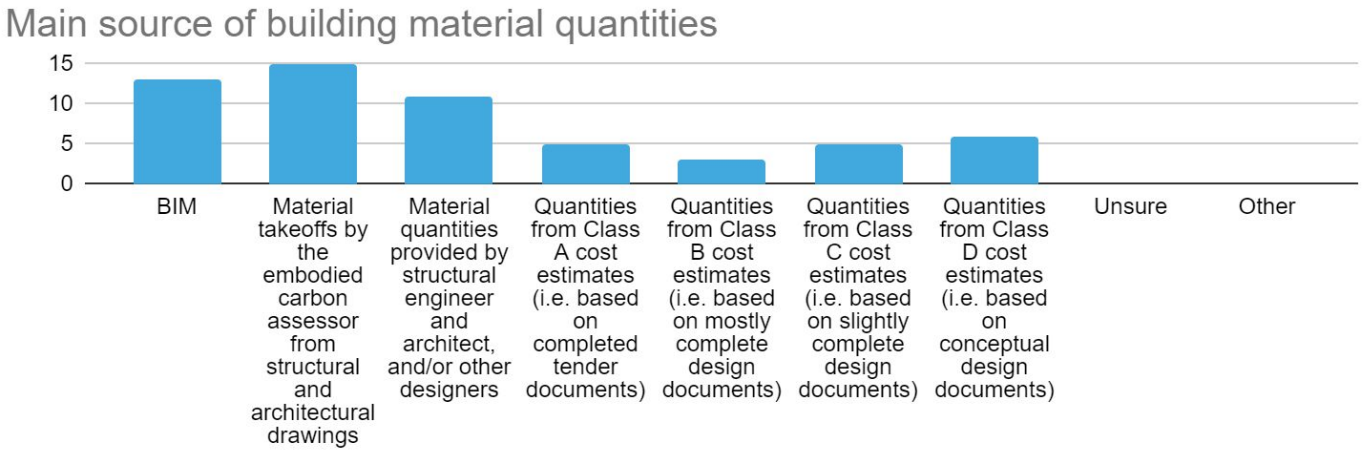
Reference study period

Mostly 60 years (LEED / CaGBC), but not all



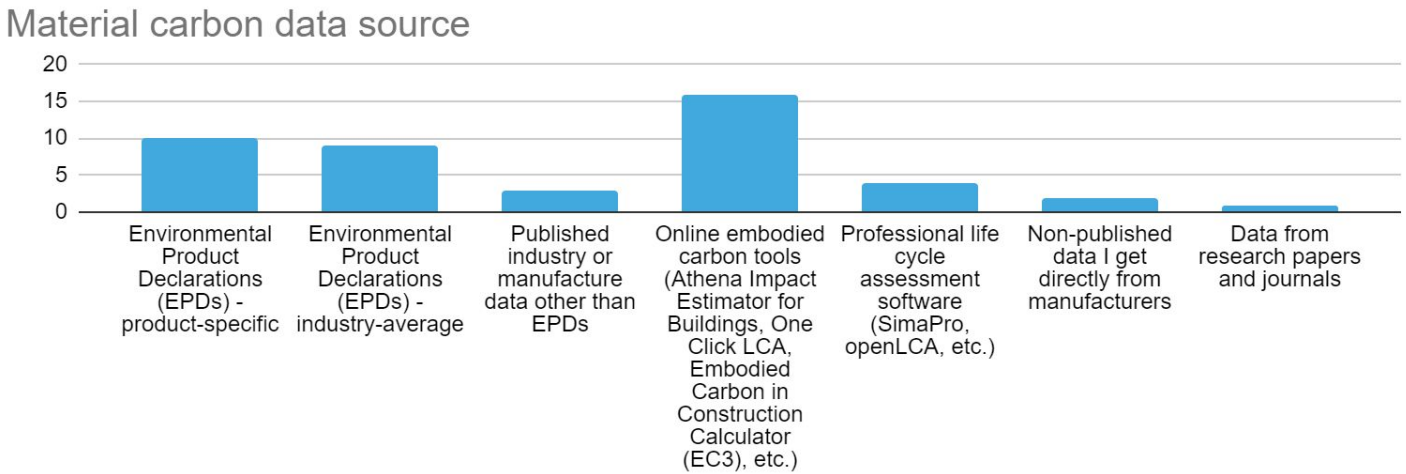
Source of material quantities

1. Material takeoffs by embodied carbon assessor
2. BIM
3. Quantities provided by design team
4. Cost estimates (ranging from Class D to Class A)



Carbon Data

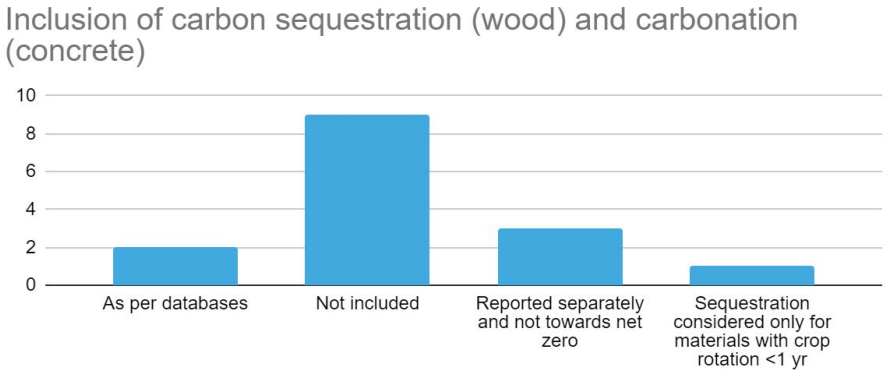
1. Online / tool database
2. Product-specific EPDs
3. Industry-average EPDs



Carbon storage: sequestration / biogenci (wood) & carbonation (concrete)

- Most don’t include carbon storage (sequestration / biogenic carbon)
- Some report separately and don’t include towards net zero balance

Answers were all regarding sequestration. Anyone who discussed carbonation (carbon absorbed by concrete) said they didn't include it and it likely is only applicable at end of life after demolition.

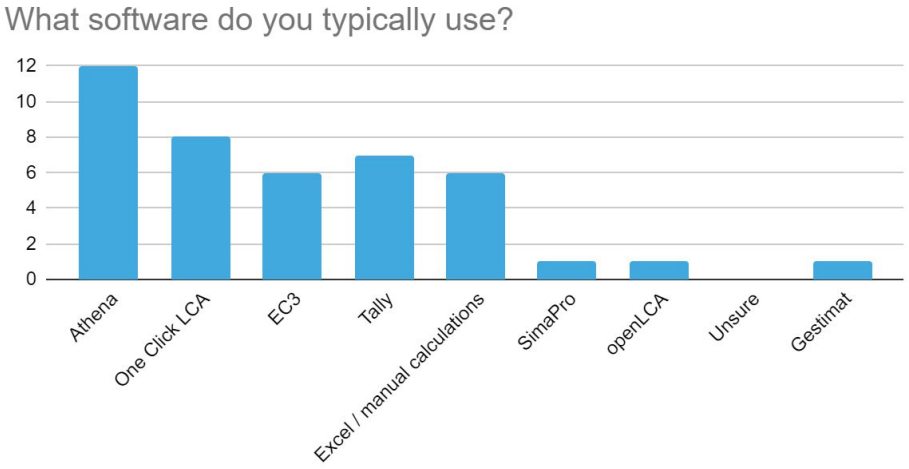


Software

1. Athena
2. One Click LCA
3. Tally
4. EC3 & Excel

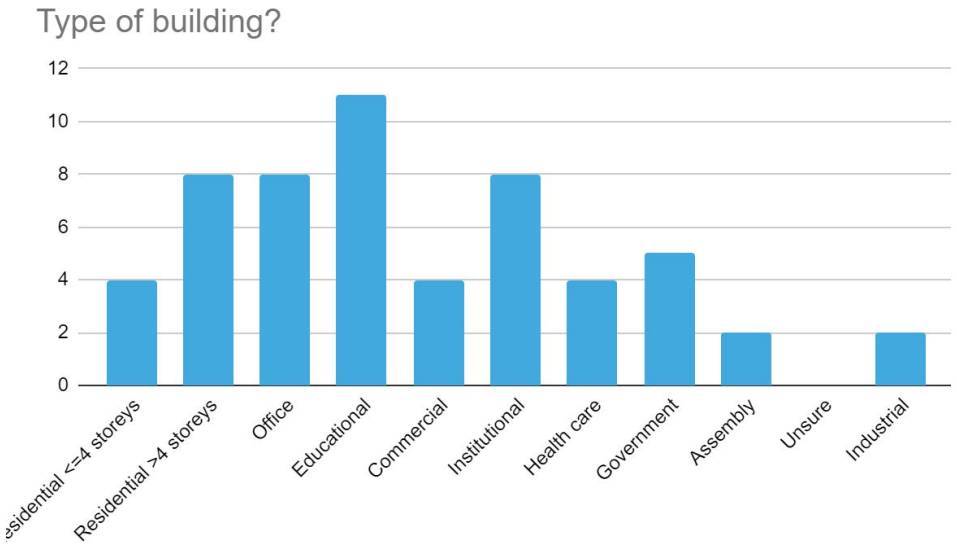
Different softwares use different assumptions and calculation methods making comparison between them difficult.

Each will give slight different answers, but isn't this also true of energy modelling software, meaning this isn't a unique problem to LCA?



Building type

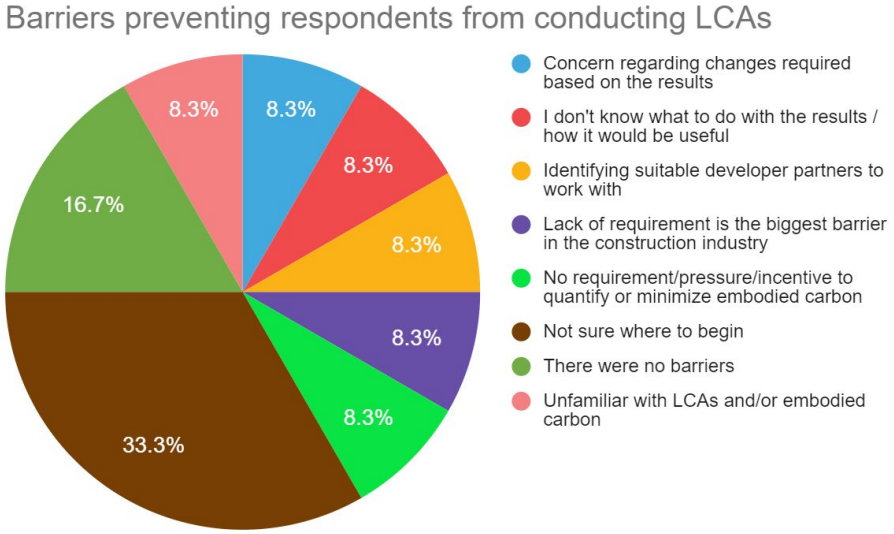
1. Educational
2. Mid/high rise res, office, institutional
3. Government



Of those yet to quantify embodied carbon

Majority are unsure of where to begin.

More basic education on the process is needed throughout the industry.



Survey 2 - LCA Data Collection

1. Respondents asked to provide project-specific whole building LCAs
2. Results were requested at the highest resolution / per life cycle stage if available (ie: A1-A3 separately from A4, separately from A5, etc).
3. Building information collected which included:
    a. area
    b. number of occupants
    c. number of storeys
    d. use and location ation
    e. primary structural system
4. Carbon sequestration values

Survey 2 - Key Takeaways

1. Embodied carbon assessments are being done across Ontario. Received results for 41 projects from 16 different respondents.
2. Projects predominantly used either One Click LCA or Athena software. The results of these tools seems to be relatively consistent (average intensity of 398* vs 434, respectively).
3. Embodied carbon intensities increase with building height due to increased materials per area and greater subsurface works.
4. Buildings with timber structures seem to have lower embodied carbon (~16% lower). Including sequestration makes this difference significant (~59% lower).
5. The vast majority (~82%) of 'upfront carbon' intensity (A1-A5) is below the 500. The mean for embodied carbon (A1-A5, B1-B5, C1-C4) is below 500.
6. 'Upfront carbon' also accounts for the vast majority of a project's total embodied carbon, on average ~90% of the data set.
7. Methodology differences make high quality comparisons between projects difficult. Any future policy should provide clear guidance for required life cycle phases, objects of assessment, material quantity data sources, and treatment of carbon sequestration.

**all values are embodied carbon (global warming potential) intensity in units of kg CO_2e/m^2*

Survey 2 - Caveat

The results provided which form the basis of our study and ‘benchmarks’ are **self-reported** by industry, were not subject to third-party validation, and represent the current range of embodied carbon / LCA results being presented in the industry for Part 3 buildings in Ontario.

The project team did not have the resources or information that would be required to review and/or revise the analyses to ensure a consistent methodology, data sources, life cycle phases, and LCA softwares across all projects, nor to offer validation of proper or complete analysis.

Comparisons between results should all be done with caution and recognizing the limitations of the data. Nevertheless, important takeaways can be gathered and suggestions for future improvements and potential policy ideas proposed.

Survey 2 - Results By LCA Assessment Tools

The average values for the two primary tools are close. Although tools may provide different results given slight methodology variations, it may not be as large a concern as some worry.

	All Tools		ONE CLICK LCA		Athena		Tally	
	Total Count	**Embodied Carbon**	Total Count	**Embodied Carbon**	Total Count	**Embodied Carbon**	Total Count	**Embodied Carbon**
All Building Types	43	**405**	33	**398**	9	**434**	1	**377**

Survey 2 Key Takeaways - Results By Primary Structural Material Type

Buildings with structural systems that are primarily timber-based seem to be lower embodied carbon than non-timber based structures (16% lower based on our sample data).

If biogenic carbon (sequestration*) is included in results, the difference is significant (59% lower).

*biogenic carbon or carbon sequestration refers to the carbon stored in wood (or other bio-based materials). It may be permanently removed from the atmosphere or returned to the atmosphere depending on building end of life decisions around reuse and waste treatment. It remains out of the atmosphere for the life of a building at minimum.

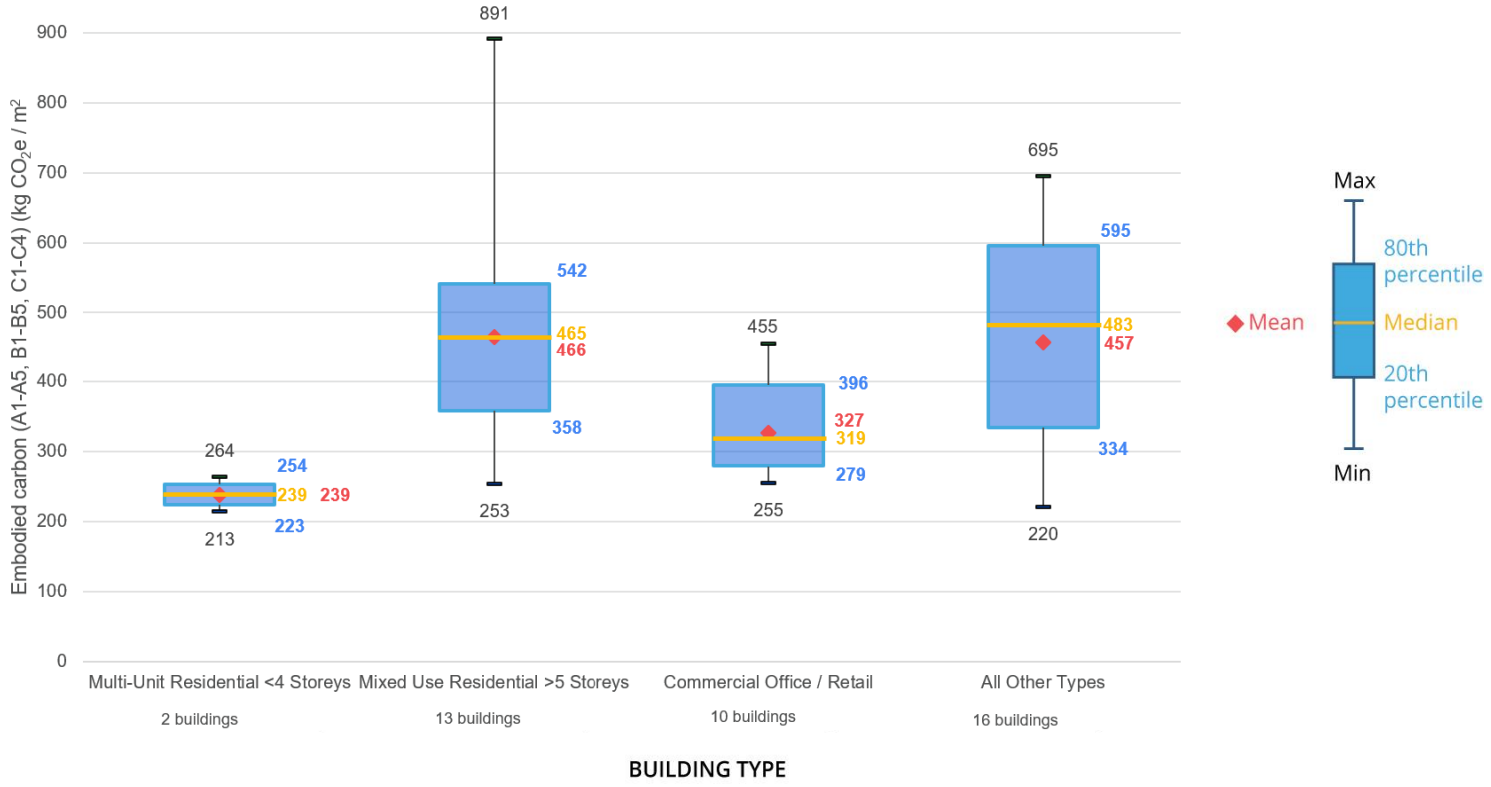
Current best practice is to report this value alongside total building embodied carbon, but not to aggregate or include in the total value reported due to uncertainty regarding future unclear end-of-life treatment.

Note that there is some ongoing debate regarding the accuracy of current timber-related LCA-based data sources given the complex forestry systems involved.

	Total Projects	Embodied Carbon	Biogenic Carbon (Sequestered Carbon)
Non-Timber Structures (30 concrete, 1 steel)	31	423	(5)
Timber-Based Structures	10	355	(182)

Survey 2 - Results By Building Type

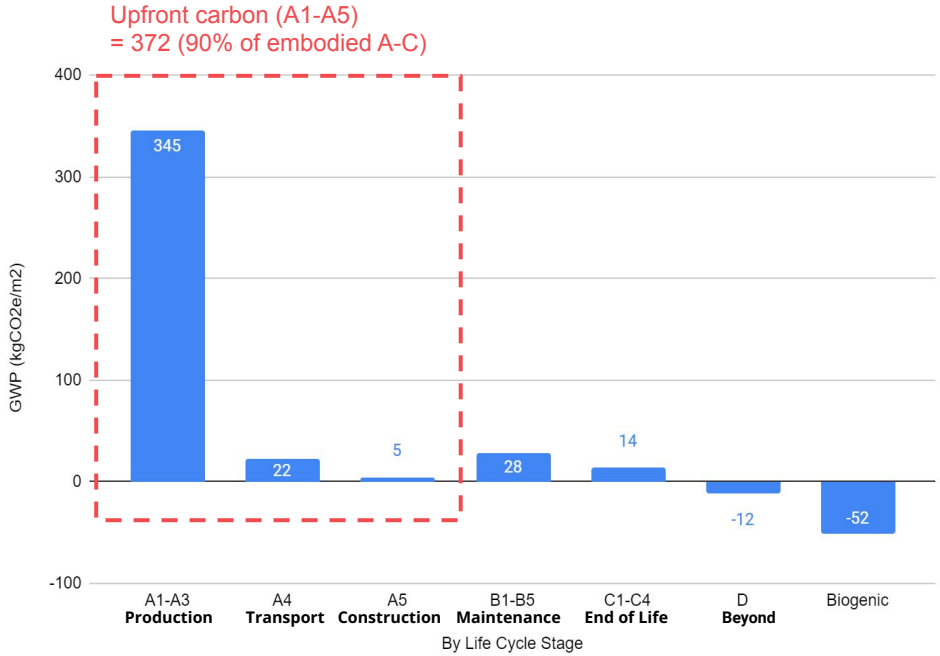
The average self-reported embodied carbon intensity for all building types is below 500 kg CO_2e/m^2 for all building types.



Survey 2 - Results By LCA Phase

The vast majority of emissions are during the material production phases.

This data represents 38 project entries (those that used One Click LCA, Tally, EC3). Athena doesn't provide this breakdown.



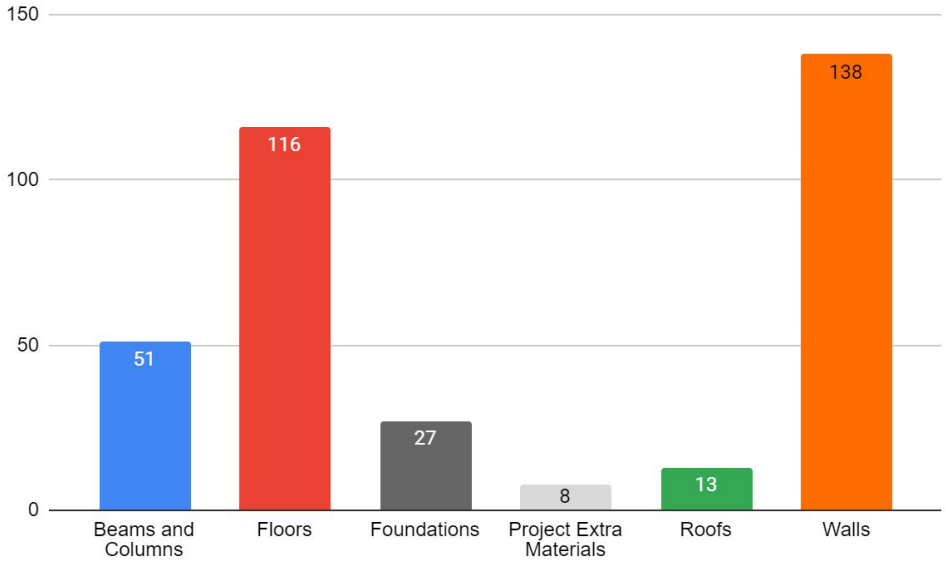
Survey 2 - Results By Building System

Walls (including envelope) and floors represent vast majority of emissions.

This data represents the 4 project entries that used Athena Impact Estimator.

The University of Toronto findings support these findings, although Foundation works would increase where underground parking is a part of the project.

*All units expressed as $kgCO_2e/m^2$



Participating Projects

Thank you to all those who provided data for this study!

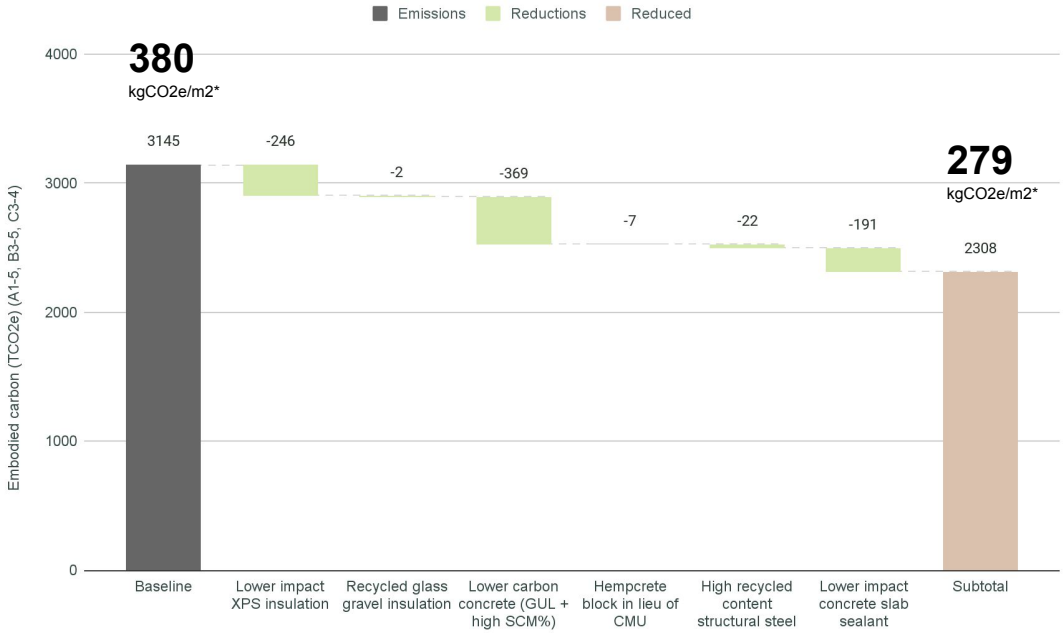
#	Owner	Project	Address	City
1	Hines Canada	T3 Bayside East	261 Queens Quay East	Toronto
2	BentallGreenOak	150 King St W	150 King St W	Toronto
3	YMCA of Greater Toronto	Stavro Family YMCA	907 Kingston Rd	Toronto
4	Ontario	Anonymous 1	N/A - Institutional Building	Eastern Ontario
5	Ontario	Anonymous 2	N/A - Institutional Building	Southwestern Ontario
6	Masenga Building Group	CORE Modern Homes	538 Eglinton Ave E	Toronto
7	Toronto Community Housing	Alexandra Park Townhouses 1B	571 Dundas St W	Toronto
8	Times Group Corporation	Bayview Villas	318-324 John Street	Markham
9	Oben Build	Oben Flats	1075 Queen St E	Toronto
10	TAS	Duke Condos	2803 Dundas St W	Toronto
11	Urban Capital Property Group	River City 2	22 Trolley Cres	Toronto
12	Tridel	SQ at Alexandra Park	38 Cameron St	Toronto
13	MOD & Woodcliffe Landmark	Waterworks	505 Richmond St W	Toronto
14	Davpart	481 University Ave	481 University Ave	Toronto
15	Lanterra Developments	Wellesley on the Park	11 Wellesley St W	Toronto
16	Mohawk College	Joyce Centre for Partnership and Innovation	Fennell Ave W	Hamilton
17	City of Toronto	Mount Dennis Childcare Centre	1234 Weston Rd	Toronto
18	Humber College	Building NX	205 Humber College Blvd	Toronto
19	Tenblock	145 St. George St.	145 St. George St	Toronto
20	Tridel and Rowntree Enterprises	Chateau Auberge on the Park	10 Inn On The Park Dr	Toronto
21	University of Toronto	Academic Wood Tower	100 Devonshire Pl	Toronto
22	Ontario Secondary Students Teachers Federation	OSSTF Building	60 Mobile Dr	North York
23	Hullmark	80 Atlantic	80 Atlantic Ave	Toronto
24	Toronto Region & Conservation Authority	TRCA Building	5 Shoreham Dr	Toronto
25	City of Toronto	Multifunction Paramedic Station	300 Progress Ave	Toronto
26	The Cora Group	evolv1	420 Wes Graham Way	Waterloo
27	Toyota Canada	Eastern Canada Parts Distribution Centre	1050 Lambs Rd	Clarington
28	Minto Communities	178-200 Isabella	178-200 Isabella	Ottawa
29	DSV	DSV Warehouse	2200 Yukon Court	Milton
30	MARS	MARS Industrial Caledon Phase 1	George Bolton Parkway	Caledon
31	Triovest Realty Advisors	iPort Caledon Building F	12300 Coleraine Dr	Bolton
32	Minto Communities	Minto Richgrove	620 Martin Grove Rd	Toronto
33	City of Toronto	Western North York Community Centre	60 Starview Lane	Toronto
34	Evergreen	TD Future Cities Centre	660 Bayview Ave	Toronto
35	BDP Quadrangle (interiors only)	The Well	TBD	Toronto
36	Defence Construction Canada	CFB Borden Apartments	620 Ortona Rd	Borden
37	Anonymous 1	Anonymous 1	Anonymous 1	Anonymous 1
38	Anonymous 2	Anonymous 2	Anonymous 2	Anonymous 2
39	Anonymous 3	Anonymous 3	Anonymous 3	Anonymous 3
40	Anonymous 4	Anonymous 4	Anonymous 4	Anonymous 4
41	Anonymous 5	Anonymous 5	Anonymous 5	Toronto

City Project - Potential Embodied Carbon Reductions through Material Substitutions

We found a 30% reduction in embodied carbon was reasonable on a specific project through six material substitutions that had minimal impact on budget and schedule.

The top three strategies alone result in over 26% reduction and 800 tonnes of avoided CO2e:

1) Lower carbon concrete
2) Lower GWP XLS Insulation
3) Lower GWP concrete sealer



*Carbon intensity for embodied carbon baseline and reduced embodied carbon scenarios

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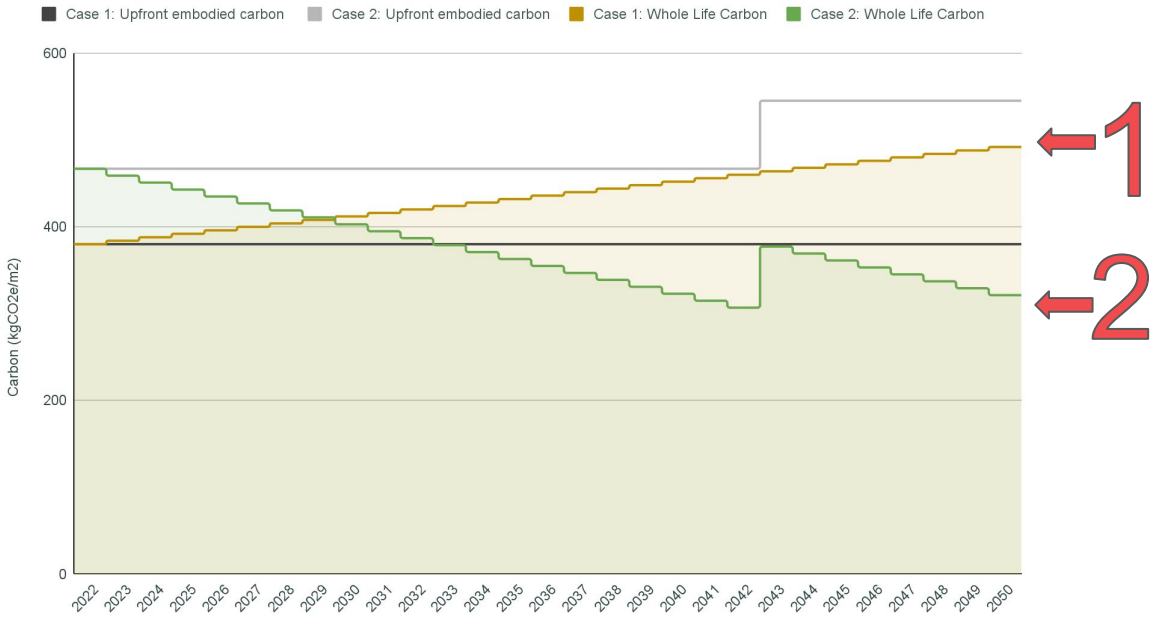
City Project - Carbon breakdown (operational and embodied) with and without solar PV panels

Solar PV system adds significant embodied carbon initially and again after 20 years when replaced.

However, total carbon is significantly reduced by using PV (case 2) vs not using PV (case 1) due to the operational carbon savings.

Embodied Carbon Against Operational Carbon with and without PV Panel systems (2022-2050). Case 2 (building with the proposed PV panels) results in a 36% reduction over Case 1 (building without PV) in terms of total project related emissions over a 28-year period.



Next steps & timing

1. Draft Toronto Green Standard recommendations. *(March-April)*
2. Hold customized workshops for the following audiences *(May and June)*:
   - City staff
   - Designers (architects, engineers, etc)
   - Manufacturers (product and material makers)
   - Developers
   - Other government officials (other municipalities, provincial, federal)
3. Develop summary primer for decision makers *(July)*

Interested to stay connected and receive invites to our workshops?

Sign up for our mailing list here

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