

MATERIAL EMISSIONS BENCHMARK REPORT FOR PART 9 HOMES IN **VANCOUVER**



Authors & Acknowledgements

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Small Works	Kingdom Builders

About Builders for Climate Action

Builders for Climate Action is working with builders, designers, developers, policy-makers, researchers and manufacturers to tackle the serious impact of buildings on our climate and work toward real zero carbon buildings.

We want to offer future generations our best efforts to reign in the worst effects of climate change through smart, coordinated and effective action to address emissions in the sector while building a world that is just and equitable.

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Executive Summary

The City of Vancouver is a world leader in addressing embodied carbon in the built environment, having set a target of reducing embodied carbon from new buildings by 40 percent by 2030. But in order to make reductions, there must first be a benchmark understanding of embodied carbon emissions in today's new homes. This study examines 13 typical new homes using as-built plans to assess the carbon footprint attributable to the structure, enclosure and partitions of these homes. Using the BEAM estimator tool, each of the 13 homes was modeled, creating a valuable data set.

Key Takeaways

- Net emissions for whole homes ranged from a low of 10.5 to a high of 140.1 tonnes of carbon dioxide equivalent (CO₂e), with an average of 43 t CO₂e.
- Emissions intensity ranged from a low of 138 to a high of 357 kilograms of CO₂e per square meter of heated floor area, with an average of 193 kg CO₂e/m².
- Emissions intensity from the sample homes in Vancouver align closely with those from a similar study in the Toronto region, which had an average emissions intensity of 191 kg CO₂e/m².
- The authors recommend that the City of Vancouver use 200 kg CO₂e/m² of heated floor area as the benchmark for embodied carbon in new Part 9 homes. To meet the target of a 40 percent reduction in embodied carbon, new homes will need to achieve an emissions intensity of 120 kg CO₂e/m² by 2030.
- The three most impactful material categories are concrete (36 percent of total emissions across all homes), insulation (21 percent) and interior surfaces (10 percent).
- A home with relatively high emissions intensity of 227 could be reduced to 127 kg CO₂e/m² by swapping just eight materials for available and competitive alternatives, coming close to meeting the 2030 reduction requirements.
- A home with relatively low emissions intensity of 138 kg CO₂e/m² could use the same eight material swaps to achieve 44 kg CO₂e/m², far surpassing the 2030 target.
- Material swaps for the best possible materials could bring homes in the study to net zero embodied carbon and even into net carbon storage.
- There appeared to be no direct correlation between embodied carbon and energy efficiency, a finding that corresponds with similar studies. It is possible to meet the highest levels of energy efficiency with a building made from low embodied carbon materials.
- The City of Vancouver should consider the metrics it will use to measure embodied carbon for incentives and regulation. This study uses emissions intensity by heated floor area, but the results are different if a metric of emissions intensity per bedroom is used.

1) Intent of Study

The City of Vancouver approached Builders for Climate Action to provide a benchmark study of material-related greenhouse gas emissions (or “up-front embodied carbon”) from new [Part 9](#) homes in the city. The results of the benchmark study are to be used for engaging with stakeholders and to help determine tiers or thresholds for incentive programs and regulations to meet the city’s [climate action plan goal](#) of reducing embodied carbon in buildings by 40 percent by 2030.

2) Scope and Method

The City of Vancouver provided the researchers with contact information for homebuilders to solicit contributions of plan sets for recently completed homes in the city. These plan sets were reviewed by city staff and a total of thirteen unique plans from eight builders were selected to be representative of new low-rise homes in the city, including single detached, single detached with suite, duplex and lane houses.

Dimensions and material selections from each set of plans were entered into the [BEAM](#) (Building Emissions Accounting for Materials) estimator tool. BEAM uses a database of available and relevant Environmental Product Declarations (EPDs) for low- and mid-rise residential construction, and applies the Global Warming Potential (GWP) factor for each material to internally-generated material quantity takeoffs based on building dimensions and specifications obtained from plan sets. BEAM provides estimates for the material related emissions (phases A1-A3 of a life cycle assessment, often referred to as “cradle-to-gate” emissions) for each material in the building’s structure, enclosure and interior partitions. This represents the bulk of each material’s life cycle emissions and represents the product categories with sufficient data sets and the majority of material mass for the homes studied. BEAM includes calculations for carbon storage in biogenic materials, and where storage is greater than A1-A3 emissions, a negative number is used to indicate net carbon storage (complete BEAM methodology can be found [here](#)). This methodology is the same used for similar studies for [NRCan](#), the cities of [Nelson and Castlegar](#) and the [Greater Toronto and Hamilton Area](#).

The researchers communicated with each builder to ensure that material selections for the plans were as accurate to the as-built homes as possible. Wherever specific products could not be determined, the researchers used average values (either industry-average EPDs or an average of each product EPD in the category) to provide a reliable, generic figure.

For each home in the study, the BEAM model provides a net emissions total for the home (Material Carbon Emissions or MCE) as well as a material emission intensity based on the square meters of heated floor area (Material Carbon Intensity or MCI). From the complete data set, the researchers characterized the overall contribution of major material categories.

The city requested the researchers to explore several variables in order to provide additional insights, including the use of low-carbon and carbon-storing materials, emissions impacts of

building on bog conditions, double- versus triple-pane windows and designing with less below-grade space. These variables were studied on selected home plans and not across the entire set of plans.

3) Results and Discussion

Overall Results

The net material carbon emissions (MCE) of homes in the study ranged from a high of 140,139 to a low of 10,466 kg CO₂e. The total emissions from the homes in the study is 558,714 kg CO₂e, with an average MCE of 42,978 per house. In 2020-21, Vancouver [reported](#) construction

Overall Results for all homes											
	Building Type	Bed rooms	Peat bog	Total floor area m ²	Above grade conditioned area m ²	Below grade conditioned area m ²	Garage * Attached garage m ²	MCE kg CO ₂ e	MCI (total floor area) kg CO ₂ /m ²	MCI heated floor area kg CO ₂ e/m ²	MCI per bdrm kg CO ₂ e/m ² /bdrm
1	Single Detached + 2 bed suite	5	Yes	248	157	70	21	80,975	327	357	71.4
2	Single Detached	4	No	580	367	251	38*	140,139	242	227	56.8
3	Lane home	1	No	53	53	0		11,560	218	218	218.0
4	Single Detached	2	No	181	166	0	15	32,522	180	196	89.0
5	Single Detached + suite	4	No	213	139	74		40,989	193	193	48.3
6	Duplex + suit	4	No	183	125	40	18	31,493	172	191	47.8
7	Lane home	1	Yes	74	74	0		14,171	191	191	191.0
8	Single Detached + suite	5	No	319	181	92	45	50,141	157	184	35.4
9	Single Detached + suite	6	No	246	150	74	22	40,215	163	180	27.3
10	Single Detached	4	No	285	167	93	25	40,468	142	156	38.3
11	Single Detached + suite	7	No	359	231	128		52,509	147	147	21.0
12	Lane home	2	No	92	95	0		13,066	142	142	71.0
13	Lane home	1+den	No	76	76	0		10,466	138	138	138.0
								MCE kg CO ₂ e	MCI kg CO ₂ e/m ²	MCI per bdrm	
Mean (average)								42,978	193	81	
Median								40,215	191		
Lowest Home Result								10,466	138	21	
Highest Home Result								140,139	357	218	
Total MCE (13 homes) 558,714											

Table 3.1. Overall results for all homes.

of 1,506 new Part 9 homes of the typologies included in this study, suggesting that annual emissions from building materials for these homes may amount to approximately 32,400 tonnes of emissions based on the average results from this study.

The material carbon intensity (MCI) was calculated by dividing the net MCE by the heated floor area of each house. MCI results ranged from a high of 327 to a low of 138 kg CO₂e/m² of heated floor area, with an average of 193 kg CO₂e/m². Table 3.1 includes the overall results for each building in the study.

The results are in alignment with similar studies of new homes in other parts of Canada, as shown in Figure 3.2. The average MCI in Vancouver of 193 kg CO₂e/m² is nearly identical to that of new homes in Toronto at 191. A narrower gap exists in the Vancouver study between the highest and lowest results compared to Toronto, potentially as a result of the smaller sample set (13 homes versus 503). Results from Nelson and Castlegar, BC, were lower than those in both Vancouver and Toronto.

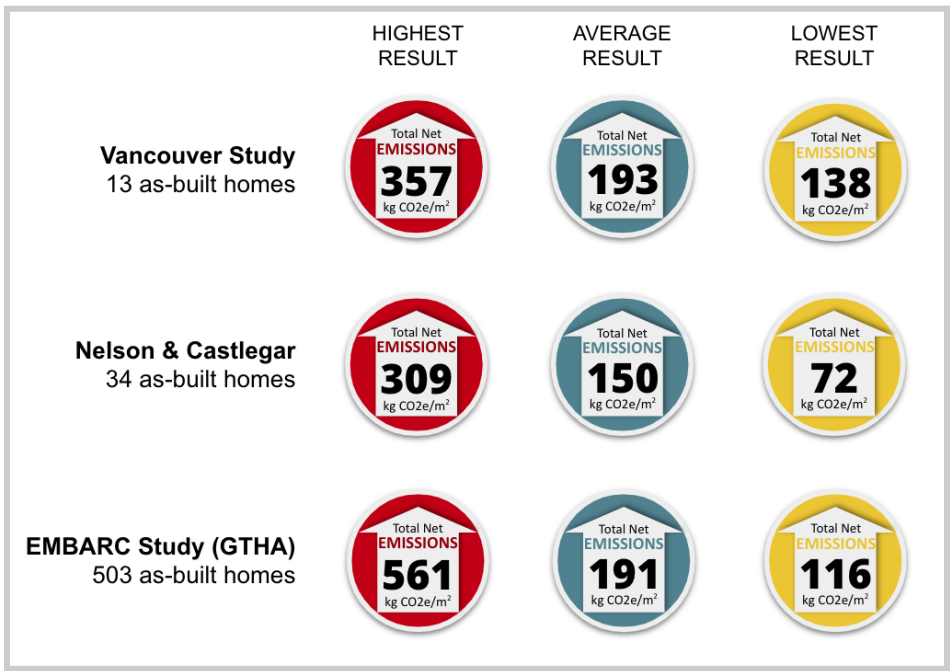


Figure 3.2. MCI results of three studies of new homes in Canada.

The researchers generated results for MCI per bedroom to indicate an additional metric that may be used to measure emission intensity. The average is 81 kg CO₂e/bedroom, and the houses with the two highest MCI rankings by heated floor area (357 and 227) are below this average when considered by the number of bedrooms (71.4 and 56.8). The City of Vancouver may want to explore the use of such an additional metric in the implementation of any program aimed at reducing embodied carbon.

MCE and Energy Efficiency

The homes examined in this study varied in their levels of energy efficiency from current code minimum standards to high efficiency voluntary standards such as Passive House, Net Zero, R2000 and Living Building Challenge.

In these homes, there was no direct correlation between the level of energy efficiency performance and material carbon emissions (Table 3.3). One home meeting Passive House standards and another the Living Building Challenge did have material carbon intensity higher than the average. Homes meeting R2000 and Step Code 4 requirements had lower than average MCI, while homes meeting Step Code 5 and Net Zero requirements were very close to the average.

From these limited results, it would appear that it is possible to meet the requirements of more stringent energy efficiency standards without raising the material carbon footprint of the homes.

MCI and Energy Efficiency		
MCI per conditioned space kg CO ₂ e/m ²	MCI per bedroom kg CO ₂ e/m ² /bdrm	Energy efficiency
357	71.3	Passive House
227	56.7	Full Living Cert. ILFI
218	218.1	Vancouver Code
196	89.0	Net Zero
192	191.5	Code min
192	48.1	Vancouver Code
191	47.7	Step 5 * not tested
184	35.4	Step Code 3
180	27.3	Vancouver Code
156	38.3	Step code 4
146	20.9	VBBL 2019, R2000
138	68.8	Code min
138	138.0	Code min
193	80.9 AVERAGES	

Table 3.3. MCI results of three studies of new homes in Canada.

MCE by Material Category

Emissions were calculated according to major material categories to provide insights on “hot spots” for potential material improvements or substitutions to reduce emissions. Figure 3.4 shows the results by emissions and percentage of the total for all houses in the study.

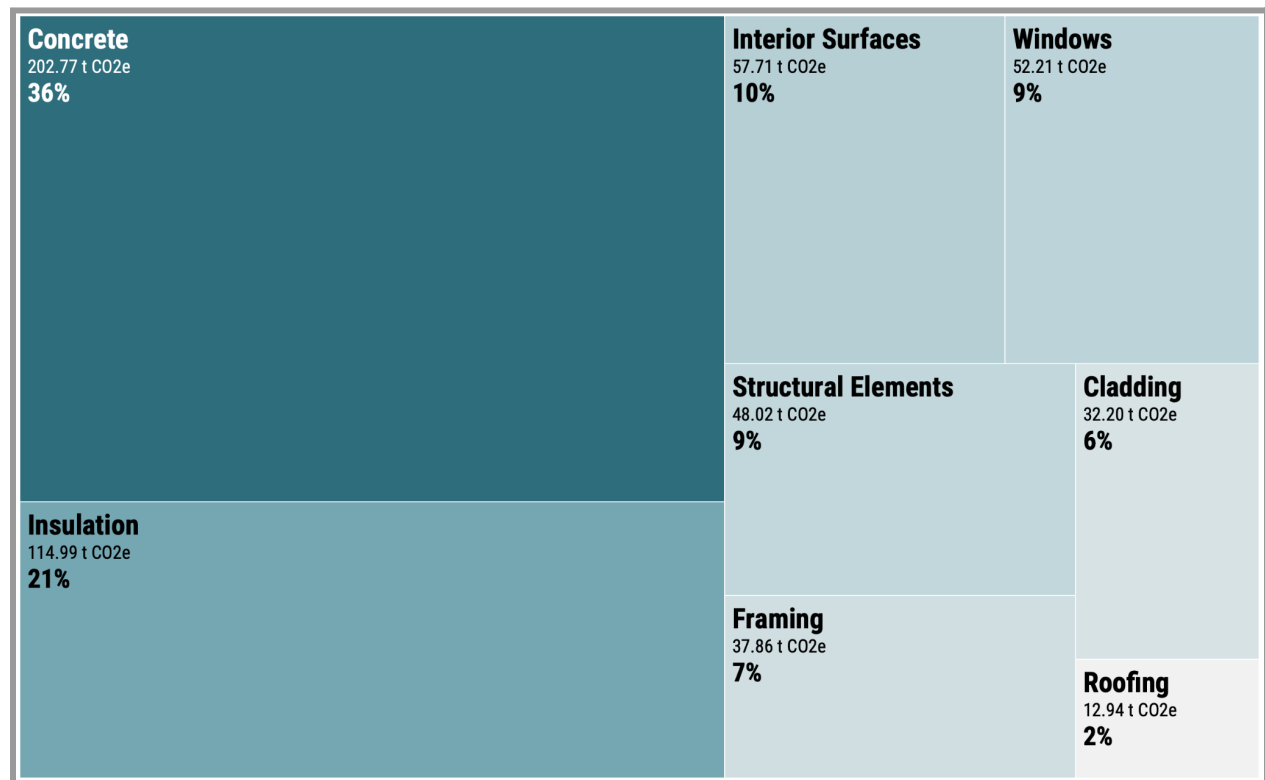


Figure 3.4. Emissions from all houses by material category.

The top three impactful material categories are concrete, insulation and interior surfaces (including wall, floor and ceiling materials), and together these three categories account for over 67 percent of total emissions from Vancouver homes.

Concrete

Studies of material emissions from new homes consistently show that concrete is the most impactful material. In this study, concrete alone represented 202.7 tonnes of emissions or an average of 15.6 tonnes per home. Across all new homes in the city this could amount to 11,750 tonnes of emissions annually (equivalent to tailpipe emissions of 2,600 automobiles).

Attributing emissions to concrete with accuracy can be problematic. The researchers were unable to use product-specific EPDs for any concrete used in the houses studied. Instead, the Canadian benchmark average emissions factor from the Canadian Ready Mix Concrete Association EPD was applied, in keeping with the methodology used in other similar studies in Canada.

Depending on the actual emissions factor of the concrete used in the houses, the results could vary significantly. At worst, using the highest value for Canadian concrete the results could be 7 percent higher than stated. Using the best product-specific result for British Columbia concrete found in the [EC3 database](#) (a free tool with the largest collection of North American building material EPDs), concrete emissions in this study could be as low as 90,562 kg CO₂e, a 55 percent reduction. Overall, concrete EPD results specific to British Columbia ready mix plants are lower than the Canadian benchmark average, with the highest BC-specific result 24 percent lower than the Canadian average.

Concrete emission values			
Data source	EPD emissions factor kg CO ₂ e/m ³	Emissions from all concrete in study kg CO ₂ e	Percent difference
Canadian benchmark average	304.5	202,774	
Lowest CRMCA result	214.4	142,769	-30%
Highest CRMCA result	327.3	217,949	+7%
Lowest BC result in EC3 database	136	90,562	-55%
Highest BC result in EC3 database	231	153,823	-24%

Table 3.5. Selected results for total concrete emissions based on different EPD values

Were the best possible concrete result used in every house in the study, concrete would become the second highest impact material category rather than the first. This variation in results indicates the importance of using product-specific concrete EPD results in order to accurately portray the emissions of any house in Vancouver. Efforts to reduce overall material emissions in Vancouver will necessarily require the use of lower carbon concrete mixes and access to product-specific EPDs.

Concrete is used in different assemblies in houses. Figure 3.6 shows the percentage of total emissions from concrete for each use type.

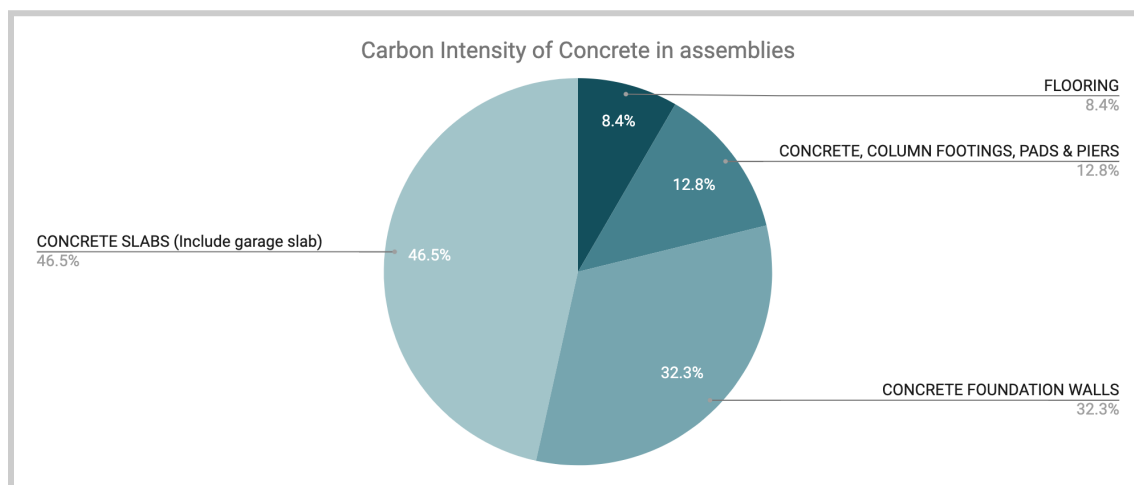


Figure 3.6. Carbon intensity of concrete in different assemblies.

Concrete slab floors represent nearly half of the total concrete-related emissions at 46.5 percent, followed by foundation walls at 32.3 percent. Substitution of low-carbon concrete in these assemblies is a leading means of reducing overall emissions. Engineered solutions to use less volume of concrete would also drive reductions. Substitution of materials other than concrete could also provide substantial reductions (see Impacts of Material Substitutions).

Insulation

The material category of “insulation” includes a wide range of products used in different parts of the houses, including sub-slab, foundation walls, exterior walls and roof. Due to the varying performance requirements for products used in each application, there is no single material improvement or substitution that can be applied to reduce emissions in this category. In each assembly of a house, there are competing insulation types with higher and lower emissions, and even within a single product category there can be significant differences in emissions. In order to lower overall emissions for insulation, material choices for each assembly in the house should be considered and the product with the lowest emissions and suitable performance specifications can be used. A number of these substitutions are considered in the section *Impacts of Material Substitutions*.

The overall contributions of different insulation materials are shown in Figure 3.7. These results are driven both by the emissions intensity of the material and the frequency of use across all the homes in the study. The large percentage of total insulation emissions attributed to mineral wool board and EPS foam board are less a result of being the highest emitters in their category and more due to the ubiquity of their use.

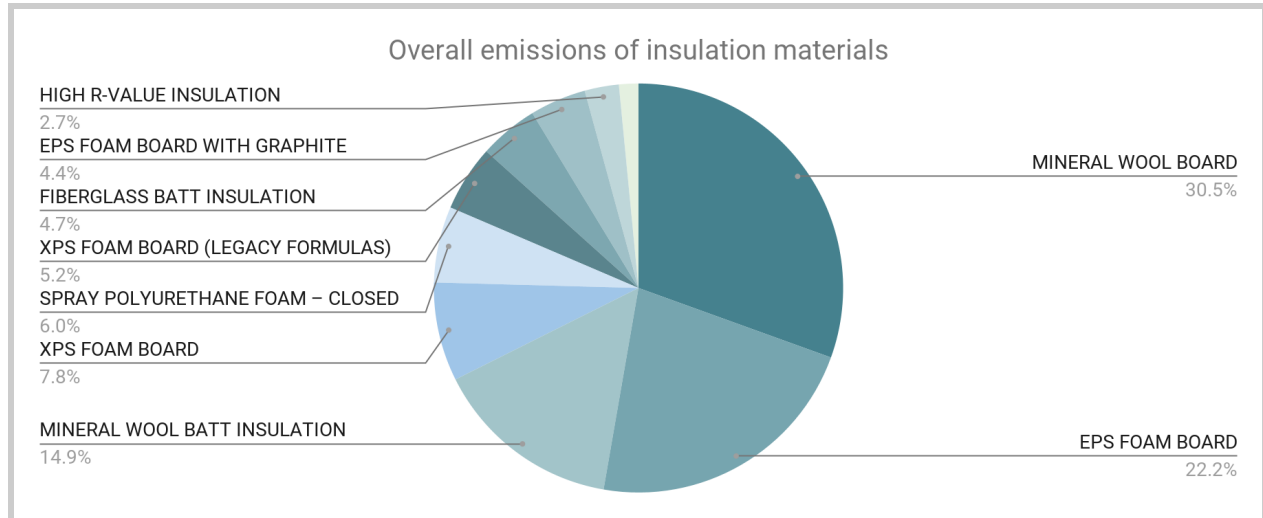


Figure 3.7. Emissions from insulation materials.

In this study, only a single house used an insulation material with net carbon storage and this is one of the leading reasons for overall emission results that are higher than other studies, where carbon-storing materials were used more frequently. Net carbon storage has a dramatic impact on overall emissions because a source of emissions is eliminated completely and an “offset” is created against emissions from other materials. The use of more carbon-storing insulation would be among the most impactful moves to reducing material emissions in this study.

Interior surfaces

Interior surfaces include wall, floor and ceiling coverings. As with insulation, the percentage of overall emissions across all the homes in the study is a result of emissions profile and volume of material used. Drywall represents 50.6 percent of emissions in this category, but has a relatively low emissions intensity of 3.27 kg CO₂e/m². Hardwood flooring is the next largest emitter in the category at 31 percent and has an emissions intensity of 15.2 kg CO₂e/m². It appears to be a higher emitter than laminate flooring (6 percent of total emissions), but laminate flooring has almost double the emissions intensity at 27.1 kg CO₂e/m² and covers only 128 m² in the study buildings, compared to 1,176 m² of hardwood.

As with the insulation category, strategies to reduce emissions include material substitutions and/or the use of products with lowest in category emissions. There were no uses of carbon-storing flooring materials in the study which can have a dramatic impact on overall emissions.

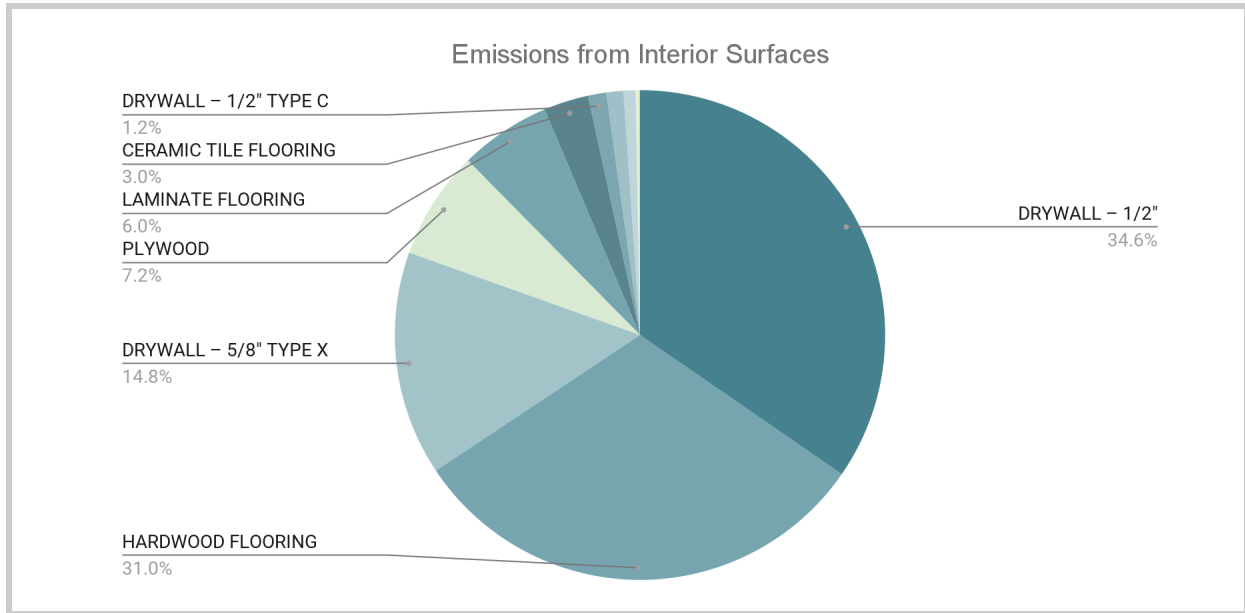


Figure 3.8. Total emissions from all interior surface materials

Cladding

Previous studies for Toronto and Nelson showed cladding as the third most impactful category of materials. However, the houses in this study used appreciably less brick and fiber cement siding which both have high emissions factors, and more wood siding which has low emissions. Figure 3.9 shows the overall results for cladding.

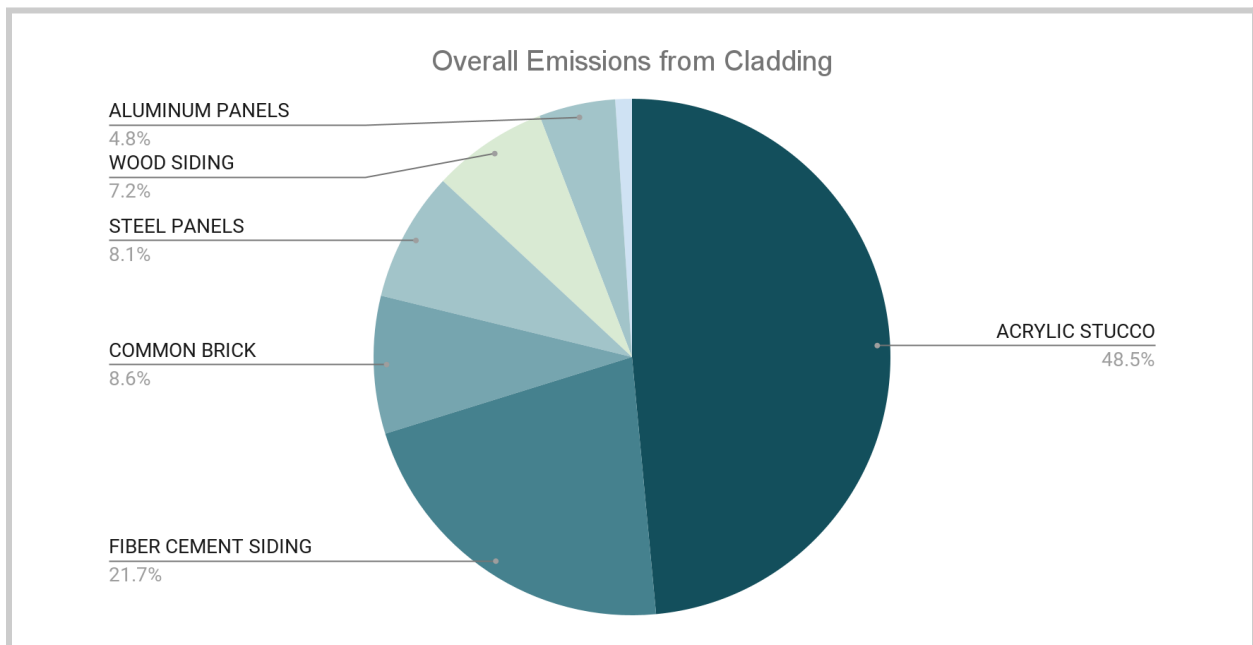


Figure 3.9. Total emissions from all cladding materials

Wood siding, which represents just 7.2 percent of emissions, covers more area at 1,612 m² than any other material in the category, but has a low emissions intensity of 1 kg CO₂e/m². Acrylic stucco was the largest contributor of emissions in the category, but covers only 476 m² across all houses.

Impacts of material substitutions

To investigate the potential for emission reductions from material substitutions, two houses were selected to make two different sets of material substitutions. The houses had as-built MCI results of 227 kg CO₂e/m² (the second highest result) and 138 kg CO₂e/m² (the lowest result).

The first set of material substitutions is called “best available materials” and inserts materials that are commercially available, code-compliant and readily interchangeable. The major substitutions include:

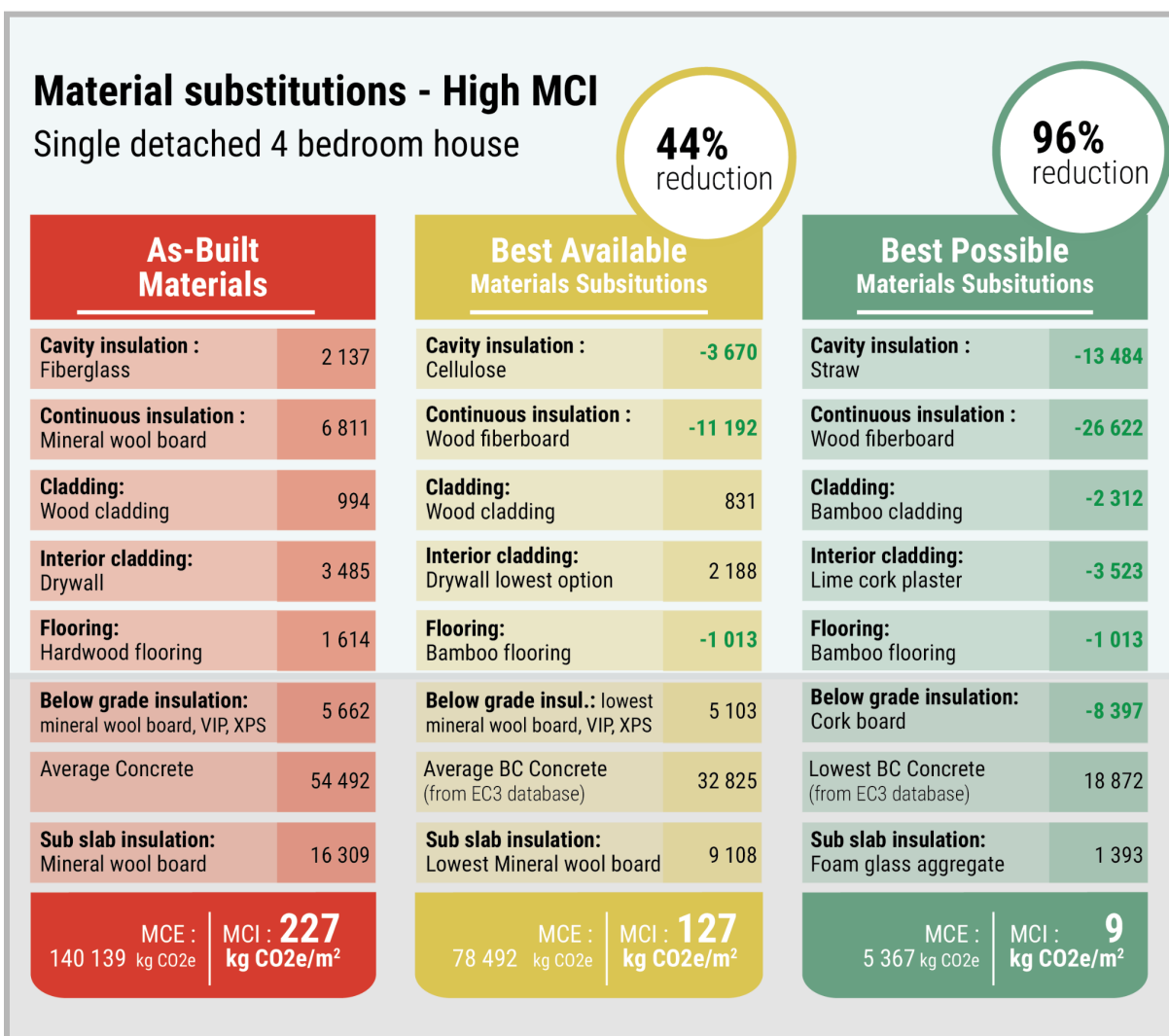
- Concrete with emissions at average of all BC concrete EPDs from EC3 database
- Cellulose insulation replaces other cavity insulation
- Wood fiberboard insulation replaces other above-grade vertical board insulation
- Bamboo flooring replaces hardwood flooring
- Where possible, best-in-category materials are specified (drywall, mineral wool, steel, XPS, EPS)

The second set of substitutions is called “best possible materials” and inserts materials that have the best emissions profile but are not necessarily widely available or code-compliant and may cost more. All “best possible materials” have some precedent in code-approved Canadian homebuilding. The major substitutions include:

- Concrete with emissions at best BC concrete EPD from EC3 database
- Foam glass aggregate replaces sub slab insulation
- Straw insulation replaces other cavity insulation
- Wood fiberboard and cork board insulation replaces other board insulation
- Bamboo flooring and cladding replace hardwood flooring and softwood siding
- Lime/cork plaster replaces drywall

Illustration 3.10 summarizes the impacts of material substitutions on both the overall MCE and the heated floor area MCI of the two houses.

The results of the material substitutions indicate that the City of Vancouver's goal of reducing embodied carbon emissions by 40 percent by 2030 is a feasible target for homebuilders to achieve. A 44 percent reduction is the smaller of the two reductions possible via substituting available and affordable materials into an existing design, slightly exceeding the city's reduction ambitions.



The results for the “best possible materials” point to the potential for new homes to approach or even exceed net zero emissions from materials. While these substitutions include some unconventional materials, all of the substitutions are for products that are commercially available in other markets. Advances in carbon-storing technologies may make these results even more achievable in the upcoming decade.

These material substitutions do not include any design changes or modifications that might require engineering. The single detached home has a substantial amount of structural steel and a very deep concrete slab, both of which contribute significant emissions and may be able to be

lowered through combined design/material considerations. These changes would likely enable the “best possible material” version of the house to reach net carbon storage. Combining design review with product specification will likely result in the best possible reductions.

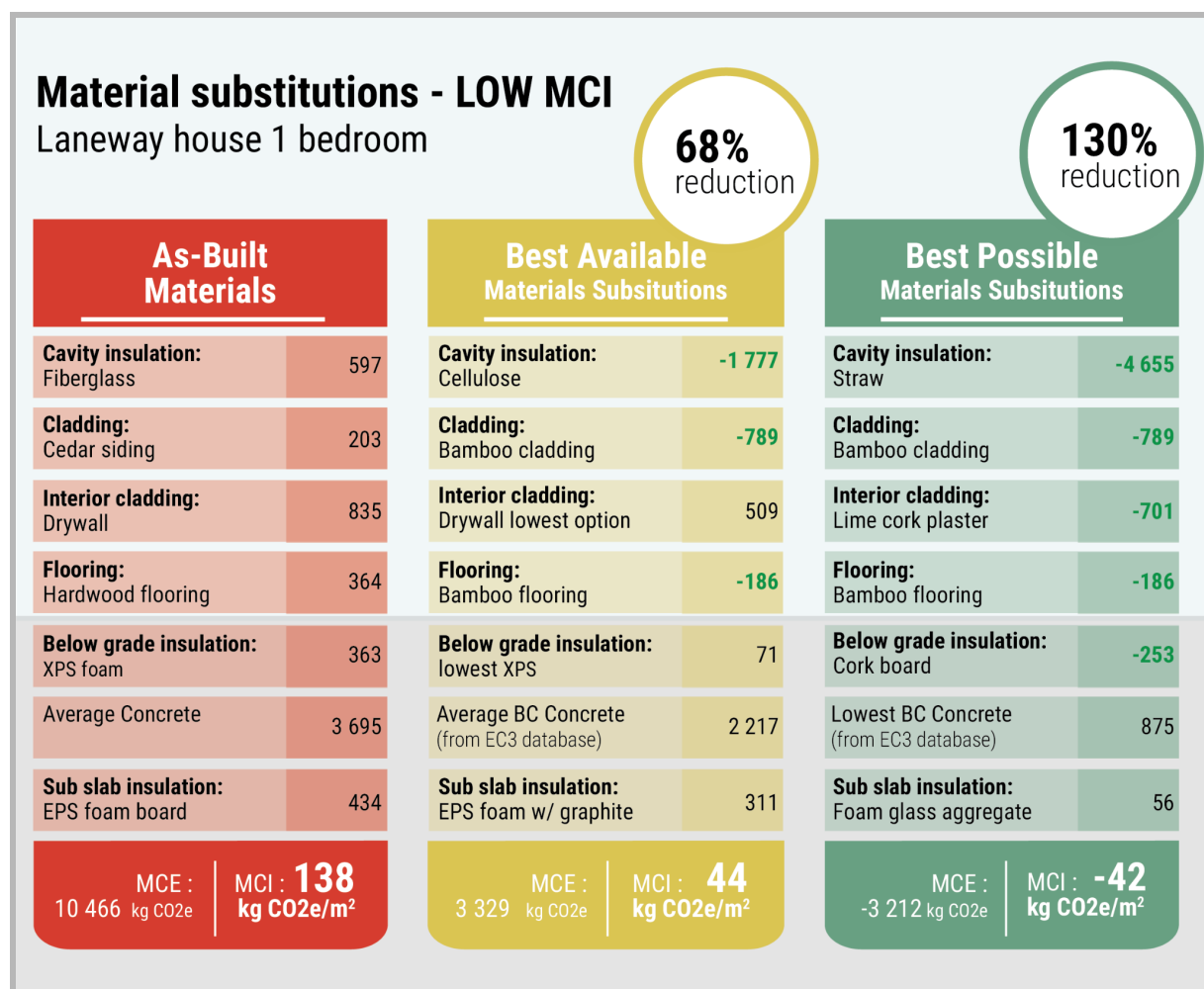


Illustration 3.10. Results of material substitutions on material emissions

The complete list of materials and substitutions can be found in [Appendix A](#) and [Appendix B](#).

A third house was subjected to material substitutions in order to explore the potential for achieving the 40 percent reduction in embodied carbon from today’s baseline. A duplex of 183 m² with an additional suite and detached garage was chosen because the as-built MCI of 191 kg CO₂e/m² was close to the average of 193. Material substitutions were made to reduce the MCI of the house close to 120 kg CO₂e/m² which would represent a 40 percent reduction in material emissions.

Only four types of substitution were need to achieve MCI of 110 kg CO₂e/m², just below the 40 percent reduction target:

- Concrete changed to the best Canadian average result (214 kg CO₂/m³). Numerous EPDs for BC concrete achieve or surpass this value.
- Cavity and roof insulation changed to cellulose
- Flooring changed to bamboo
- High volume materials (drywall, shingles, steel, XPS) changed to best available products

These substitutions are cost-competitive and would not result in any variation in the appearance or functionality of the house. This suggests that a 40 percent reduction is achievable in houses with an average level of MCI.

The complete list of materials and substitutions for this house can be found in [Appendix C](#).

Impacts of double versus triple pane windows

Vancouver has taken important and effective steps to make homes more energy efficient and therefore generate less operating emissions. One strategy used by energy efficient home designers is to use triple pane windows instead of double panes because of the higher thermal performance offered by the additional air gap and pane of glass in these windows.

To examine the material carbon impacts of this decision, the researchers obtained energy models for two homes in the study and requested the substitution of double pane windows into the models to compare the impacts on operating emissions. The same substitutions were made in the BEAM models to compare the material emissions.

2-Bedroom lane home at Code minimum energy performance		MCE of the home (t CO ₂ e)	Annual operational emissions (t CO ₂ e/year)
Main	Double pane window - Vinyl frame	13.066	6.831
Alternate 1	Triple pane window - Vinyl frame	13.333	6.799
	Increase in MCE	0.267	
	Decrease in operational emissions		-0.032
Years of operational savings to equal additional MCE			8.3 years

Table 3.11. Operational and embodied emission impacts of window glazing.

The first house is a 2-bedroom lane home that meets code minimum standards for energy efficiency. The house is fitted with double pane windows. The substitution to triple pane windows would increase the net MCE by 0.267 tonnes (2 percent of total MCE) and would reduce annual operational emissions by 0.032 tonnes per year. In 8.3 years, the additional emissions from the

more intensive triple pane windows would be offset by the improved performance of the windows (see Table 3.11).

In the second case, a single detached home meets Net Zero Energy standards and specified triple pane windows. A PV system is used to offset operational emissions and is modeled to produce more energy than it consumes on an annual basis.

Substituting double pane windows into this model reduced MCE by 0.623 tonnes (2 percent of total MCE). The decrease in thermal performance did not have an impact on operational emissions because it would still meet net zero requirements and match its energy consumption with PV generation. In this case, the additional material emissions required for the triple pane windows will never be compensated by reduced operational emissions (see Table 3.12).

Single detached home Net zero energy performance with PV		MCE of the home (t CO ₂ e)	Annual operational emissions (t CO ₂ e/year)
Main	Double pane window - Vinyl frame	29.495	0
Alternate 1	Triple pane window - Vinyl frame	28.872	0
	Decrease in MCE	-0.623	
	Decrease in operational emissions		0
Years of operational savings to equal additional MCE			N/A

Table 3.12. Operational and embodied emission impacts of window glazing.

In both cases, the move to triple pane windows impacts overall MCE by 2 percent. Such a relatively small increase or decrease in MCE can be offset by other material substitutions (see Impacts of Material Substitution section) and is not likely to be a leading strategy for reducing overall MCE. If triple pane windows are not necessary to achieve zero operational emissions and other performance factors (such as thermal comfort, condensation and air tightness) the use of double pane windows can provide some small MCE reductions. In general, this study indicates that MCE is not necessarily a leading factor in such decisions.

Impacts of reducing below grade living space

Current home designs in Vancouver often include substantial below-grade living space in the form of concrete basements. Two homes with full basements were examined to determine the impacts of raising the house higher above grade, from a full (8-foot) basement to a half (4-foot) basement and to a slab-on-grade design. In each scenario, the elements of the existing frame wall system were applied to the new above-grade areas of the house. Table 3.13 summarizes the results of these changes to below-grade space.

Impacts of reducing below-grade space for two Vancouver houses				
		MCE kg CO ₂ e	MCI kg CO ₂ e/m ² of heated floor area	Percentage reduction
House 1	As built	52509	147	-
	4-foot foundation depth	50480	141	4%
	Slab on grade	47931	134	9%
	As built with 45% reduction in concrete emissions	48423	135	8%
House 2	As built	40989	193	-
	4-foot foundation depth	39189	184	5%
	Slab on grade	37441	176	9%
	As built with 45% reduction in concrete emissions	38051	179	7%

Table 3.13. Results of reducing below-grade space on MCE and MCI

Bringing the entire house area above grade and using a slab-on-grade foundation reduces the overall emissions of both homes by 9 percent, and maintaining four feet of below grade area reduces emissions by about half, at 4-5 percent. Maintaining the full concrete basement but ensuring the concrete is a low-emission mix (in this case using the average of all BC-specific concrete EPDs from the EC3 database, at 183.5 kg CO₂e/m³) has almost the same effect as moving the building above grade, at 7-8 percent reductions.

All versions of the two houses maintain the use of a concrete slab floor for the bottom level, and these slabs use a substantial proportion of the overall concrete use. Regardless of how deep below grade the slab lies, it continues to be a big part of the emission profiles of the houses. Substituting the concrete slab for a clay-based slab or for a plywood “slabless slab” would reduce emissions in all of the scenarios. A sample home with a 193m² slab floor has 6,516 kg of emissions for concrete and steel mesh, but would have only 1,449 kg of emissions for a wood-based slab floor with 2x4 sleepers and two layers of 5/8-inch plywood on top, suggesting such a strategy might be among the most impactful reductions.

These results may suggest that there are not substantial emission reductions to be had from minimizing or eliminating basements. However, neither house uses a low-carbon wall system for its above-grade walls. If house 2 used cellulose and wood fiberboard insulation for its exterior walls, the impact of having all the exterior walls above grade is substantial, reducing the overall MCE to 27,279 kg CO₂e and the MCI to 128 kg CO₂e/m², a 33 percent reduction. This indicates that simply raising homes higher above grade will not have a substantial impact on overall emissions, but taking advantage of the ability to use carbon-storing materials in the increased above grade wall area will have a significant impact.

Impacts of building on bog conditions

Some sites in Vancouver have “bog” soil conditions that necessitate additional structural materials in order to provide a stable foundation for a house.

Two of the houses in this study are built on bog conditions, and the steel piles and beams used to meet the structural requirements are substantial. For the single family home with two attached suites, the steel piles and beams (included in the “structural materials” category in BEAM) required for the bog foundation total 22,329 kg CO₂e, representing 23 percent of the total MCE for the house.

The structural materials for these two houses built on bogs represent 47 percent of the total in this category for all 13 homes in study, indicating that it will be more difficult – but not impossible – to meet low-carbon targets when homes are built on sites with bog conditions.

4) Recommendations

1. **Baseline MCI of 200 kg CO₂e/m².** Based on the average net MCI in this study of 193 kg CO₂e/m², it is recommended that the City of Vancouver use a rounded baseline of 200 kg CO₂e/m² of heated floor area to represent the typical average emissions for new homes. This baseline should be based on the A1-A3 (cradle-to-gate) emissions for all structure, enclosure and partition materials.

A baseline of 200 kg CO₂e/m² would mean the city’s intended 40 percent reduction by 2030 would bring MCI down to 120 kg CO₂e/m². Material substitutions for a small number of available and affordable materials were shown to bring MCI for a house with near-average MCI of 191 kg CO₂e/m² down to 110, indicating that the city’s targets are achievable. A larger set of substitutions of available, affordable and code-compliant materials was shown to reduce MCI by 65 percent, from 138 to 49 kg CO₂e/m², indicating that even more substantial reductions are feasible in the near term. This sample house was able to achieve net carbon storage using materials that are feasible but not widely used or available, indicating that embodied carbon from new houses can be brought to zero in the coming decades.

2. **Selection of metrics for measuring embodied carbon.** The metric used for comparison in this study is kilograms of carbon dioxide equivalent per square meter of heated floor area (kg CO₂e/m²). Dividing net emissions for a whole house by floor area enables reasonable comparisons across different house sizes and is recommended. Using heated floor area rather than total floor area includes a bias against floor area that is not part of the conditioned, livable space (such as garages and unheated basements) as emissions for these spaces will be “added” to the heated floor area, raising MCI by an average of 7 percent in this study.

MCI was also calculated by dividing net emissions for a whole house by the number of bedrooms, as a way to attribute emissions to occupants rather than buildings. This can radically change the results, as houses with higher than average MCI based on heated floor area were often below the average for MCI based on occupant.

The City of Vancouver should consider what definition of floor area to use and whether or not to combine additional metrics such as MCI per occupant.

3. **Regulate whole buildings, not individual materials.** This study calculates emissions from whole houses (including all structure, enclosure and partition materials, but excluding MEP, appliances, millwork and surface finishes) to achieve net emissions for the house as well as emissions by floor area and occupant. It is recommended that some version of whole-house measurement is used and that the regulation of specific materials be avoided. Material substitutions at the whole house level indicate that even if some high-emission materials are used, a reasonable level of emissions can be achieved. Regulating whole buildings ensures that homebuilders have the greatest flexibility to achieve appropriate emissions levels and avoids the need to directly regulate individual material types for which emissions are constantly improving.
4. **Concrete.** Concrete is the leading contributor to emissions from the sample houses, representing over 36 percent of all material emissions. The use of Canadian average data for concrete emissions may have overstated the impact of concrete, but no product-specific data was available. Ensuring that product-specific EPDs for concrete are available and used in calculations will help to ensure that the city's targets are being met accurately. Reducing the amount of concrete used in house designs and specifying low-emission concrete are two of the leading strategies for meeting the city's reduction goals.
5. **Insulation.** Insulation was the second largest contributor to emissions from the sample houses. Carbon-storing insulation materials were not commonly used in the sample houses, but the results of the material substitution study indicate that the use of carbon-storing insulation materials is a leading strategy to reduce emissions.
6. **Embodied and operational emissions.** The houses in the study achieve a range of energy performance levels, from code minimum to net zero ready and Passive House. There was no direct correlation between embodied emissions and energy efficiency level, with some highly efficient homes also achieving lower than average MCI. The City of Vancouver does not need to adjust its performance requirements in order to achieve its desired embodied carbon reductions.
7. **Double- and triple-pane windows.** The impact of using double versus triple pane windows was not a substantial driver of embodied carbon or operational emissions in the two homes studied. The City of Vancouver does not need to specify window selections in any embodied carbon program.

8. **Below grade living space.** Minimizing below-grade living space can achieve embodied carbon reductions by around 9 percent if no other changes are made to the design or assemblies. However, the potential to reduce emissions through the use of low-carbon concrete, alternatives to concrete slabs and the use of low-carbon and carbon storing materials throughout the house means the city does not need to impose restrictions on below-grade construction in order to meet embodied carbon reductions.
9. **High impact of bog foundations.** Building on bog conditions can raise embodied carbon. The two homes in the study built on bog had 23 percent of their total emissions arise from the foundation materials required. Houses built in bog areas should still be able to meet the city's reduction requirements by using the best available materials for foundations and using a suitable percentage of carbon storing materials in other parts of the house.

Appendices

Appendix A

Van 03 High MCI As built

REVIEW PROJECT MATERIALS			140,139	140,139	0
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONCRETE SLABS	Concrete – 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	19,978	19,978	0
Footings & Slabs	REBAR FOR SLABS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 20M	4,717	4,717	0
Footings & Slabs	SUB-SLAB INSULATION	Mineral wool board - heavy density / NAIMA / R 4.2/inch [Industry Avg N.America]	16,309	16,309	0
Footings & Slabs	ADDITIONAL MATERIALS	Mineral wool board - heavy density / NAIMA / R 4.2/inch [Industry Avg N.America]	1,992	1,992	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	5,755	5,755	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	8,496	8,496	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete – 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	13,476	13,476	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 13M	5,091	5,091	0
Foundation Walls	CONTINUOUS INSULATION	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	1,608	1,608	0
Foundation Walls	INTERIOR WALL CLADDING	Drywall 1/2" [BEAM Avg US & CA]	504	504	0
Foundation Walls	ADDITIONAL MATERIALS	Vacuum Insulated Panel / Porextherm / Vacuapor / R 30/inch	3,134	3,134	0
Foundation Walls	ADDITIONAL MATERIALS	XPS foam board / R 5.0/inch [BEAM Avg US & CA]	920	920	0
Foundation Walls	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	301	301	0
Structural Elements	STRUCTURAL TIMBER	Glued Laminated Timber (Glulam) / AWC & CWC [Industry Avg US & CA]	796	796	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W250x7 (US W10x45) / ASC [Industry Avg US]	490	490	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W360x45 (US W14x22) / ASC [Industry Avg US]	748	748	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W410x74 (US W16x50) / ASC [Industry Avg US]	1,185	1,185	0
Structural Elements	STRUCTURAL STEEL – OTHER SECTION SHAPES	Structural Steel / Square HSS / 4 x 4 x 1/4" / ASC [Industry Avg US]	5,005	5,005	0
Structural Elements	STRUCTURAL STEEL – OTHER SECTION SHAPES	Structural Steel / Square HSS / 5 x 5 x 1/4" / ASC [Industry Avg US]	1,884	1,884	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	91	91	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	427	427	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	1,444	1,444	0
Exterior Walls	CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	468	468	0
Exterior Walls	CONTINUOUS INSULATION	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	3,474	3,474	0
Exterior Walls	ADDITIONAL MATERIALS	Fiberglass batt / R 3.6/inch [BEAM Avg]	98	98	0
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	831	831	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 1/2" [BEAM Avg US & CA]	876	876	0
Exterior Wall Cladding	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	268	268	0
Exterior Wall Cladding	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	58	58	0
Windows	WINDOWS – DOUBLE-GLAZED	Window - double-glazed / Fiberglass frame / BICA Study [US & CA]	11,867	11,867	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg US & CA]	33	33	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	463	463	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	86	86	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" [BEAM Avg US & CA]	682	682	0
Interior Walls	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	61	61	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	437	437	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	105	105	0
Floors	LAMINATED TIMBER FLOOR PANELS	Cross Laminated Timber / Structural / CrossLam / 3-1/2"	4,461	4,461	0
Floors	FLOORING	Hardwood flooring / CRAFT Artisan Wood Floors / Engineered / 5/8", SFI Certified	1,614	1,614	0
Floors	ADDITIONAL MATERIALS	Mineral wool batt / [BEAM Avg]	84	84	0
Floors	ADDITIONAL MATERIALS	Mineral wool batt / [BEAM Avg]	115	115	0
Floors	ADDITIONAL MATERIALS	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	119	119	0
Floors	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	6,486	6,486	0
Ceilings	CEILING FINISHES	Drywall 1/2" [BEAM Avg US & CA]	1,045	1,045	0
Roof	WOOD ROOF FRAMING	Wood / joist / LH 230/360 / 14" Depth / AWC & CWC [Industry Avg US & CA]	784	784	0

BEAM Buildings Emission Assessment Method the sustainable BUILDERS FOR CLIMATE ACTION REVIEW PROJECT MATERIALS			140,139	140,139	0
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Roof	ROOF DECKING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	877	877	0
Roof	WATERPROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, KO, Johns Mansville, Malarkey, Siplast, Soprema /	1,407	1,407	0
Roof	ROOF CAVITY INSULATION	Fiberglass loose fill / ~R2.6/inch [BEAM Avg]	1,185	1,185	0
Roof	CONTINUOUS ROOF INSULATION	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	2,494	2,494	0
Garage	GARAGE SLAB FLOOR	Concrete ~ 31.35 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	1,345	1,345	0
Garage	REINFORCING MESH FOR GARAGE SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	69	69	0
Garage	LIGHT WOOD FRAME EXTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	95	95	0
Garage	EXTERIOR WALL CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	104	104	0
Garage	EXTERIOR WALL CONTINUOUS INSULATION	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	679	679	0
Garage	LIGHT WOOD FRAME GARAGE PARTITION WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	103	103	0
Garage	GARAGE PARTITION WALL CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	122	122	0
Garage	INTERIOR CLADDING	Drywall 1/2" [BEAM Avg US & CA]	165	165	0
Garage	INTERIOR CLADDING	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	110	110	0
Garage	INTERIOR CLADDING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	102	102	0
Garage	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	282	282	0
Garage	EXTERIOR WALL CLADDING	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	163	163	0
Garage	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Fiberglass frame / EHCA Study [US & CA]	103	103	0
Garage	CEILING FINISHES	Drywall 1/2" [BEAM Avg US & CA]	103	103	0
Garage	ROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, KO, Johns Mansville, Malarkey, Siplast, Soprema /	25	25	0
Garage	CONTINUOUS ROOF INSULATION	Mineral wool board / Rockwool / Rockboard 66 / R 4.3/inch	45	45	0
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / Crosslam / 3-1/2"	61	61	0
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / Crosslam / 3-1/2"	1,474	1,474	0
Garage	ADDITIONAL MATERIALS	Fiberglass batt / R 3.6/inch [BEAM Avg]	160	160	0

Van 03 High MCI Best available materials

REVIEW PROJECT MATERIALS			78,492	108,146	29,654
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONCRETE SLABS	Concrete – 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	11,308	11,308	0
Footings & Slabs	REBAR FOR SLABS	Rebar / ArcelorMittal Long Products Canada / 15M	4,129	4,129	0
Footings & Slabs	SUB-SLAB INSULATION	Mineral wool board / Rockwool / Comfortboard 80 / R 4.2/inch	8,117	8,117	0
Footings & Slabs	ADDITIONAL MATERIALS	Mineral wool board / Rockwool / Comfortboard 80 / R 4.2/inch	991	991	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	3,453	3,453	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	5,098	5,098	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete – 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	8,086	8,086	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Nucor Corporation / 15M	4,487	4,487	0
Foundation Walls	CONTINUOUS INSULATION	Mineral wool board / Rockwool / Rockboard 60 / R 4.3/inch	1,608	1,608	0
Foundation Walls	INTERIOR WALL CLADDING	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	307	307	0
Foundation Walls	ADDITIONAL MATERIALS	Vacuum Insulated Panel / Porotherm / Vacuor / R 30/inch	3,134	3,134	0
Foundation Walls	ADDITIONAL MATERIALS	XPS foam board / SOPREMA / SOPRA XPS / R 5.0/inch	361	361	0
Foundation Walls	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	181	181	0
Structural Elements	STRUCTURAL TIMBER	Glued Laminated Timber (Glulam) / AWC & CWC [Industry Avg US & CA]	796	796	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W250x67 (US W10x45) / AISC [Industry Avg US]	490	490	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W360x45 (US W14x22) / AISC [Industry Avg US]	748	748	0
Structural Elements	STRUCTURAL STEEL – WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W410x74 (US W16x50) / AISC [Industry Avg US]	1,185	1,185	0
Structural Elements	STRUCTURAL STEEL – OTHER SECTION SHAPES	Structural Steel / Square HSS / 4 x 4 x 1/4" / AISC [Industry Avg US]	5,005	5,005	0
Structural Elements	STRUCTURAL STEEL – OTHER SECTION SHAPES	Structural Steel / Square HSS / 5 x 5 x 1/4" / AISC [Industry Avg US]	1,884	1,884	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	91	91	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	427	427	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	1,444	1,444	0
Exterior Walls	CAVITY INSULATION	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-1,242	339	1,581
Exterior Walls	CONTINUOUS INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6/inch, 40, 60, 80, 100, 120, 140, 160, 180, 200 mm	-5,810	5,886	11,696
Exterior Walls	ADDITIONAL MATERIALS	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-261	71	332
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	831	831	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	534	534	0
Exterior Wall Cladding	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	268	268	0
Exterior Wall Cladding	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	58	58	0
Windows	WINDOWS – DOUBLE-GLAZED	Window - double-glazed / Fiberglass frame / BHCA Study [US & CA]	11,867	11,867	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg US & CA]	33	33	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	463	463	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	86	86	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	416	416	0
Interior Walls	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	61	61	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	437	437	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	105	105	0
Floors	LAMINATED TIMBER FLOOR PANELS	Gross Laminated Timber / Structurlam / CrossLam / 3-1/2"	4,461	4,461	0
Floors	FLOORING	Hard Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 13mm (1/2"), High Density	-1,013	1,205	2,218
Floors	ADDITIONAL MATERIALS	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-88	24	112
Floors	ADDITIONAL MATERIALS	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-121	33	154
Floors	ADDITIONAL MATERIALS	Mineral wool board / Rockwool / Rockboard 60 / R 4.3/inch	119	119	0
Floors	ADDITIONAL MATERIALS	Concrete – 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	3,892	3,892	0
Ceilings	CEILING FINISHES	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	637	637	0
Roof	WOOD ROOF FRAMING	Wood joist / IJI 230/360 / 14" Depth / AWC & CWC [Industry Avg US & CA]	784	784	0



REVIEW PROJECT MATERIALS

78,492

108,146

29,654

SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Roof	ROOF DECKING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	877	877	0
Roof	WATERPROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, KO, Johns Mansville, Malarkey, Siplast, Soprema /	1,407	1,407	0
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / R 3.7/inch / CIMA [Industry Avg US & CA]	-1,258	576	1,834
Roof	CONTINUOUS ROOF INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6/inch, 40, 60, 80, 100, 120, 140, 160, 180, 200 mm	-4,171	4,225	8,397
Garage	GARAGE SLAB FLOOR	Concrete - 31:35 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	807	807	0
Garage	REINFORCING MESH FOR GARAGE SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	69	69	0
Garage	LIGHT WOOD FRAME EXTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	95	95	0
Garage	EXTERIOR WALL CAVITY INSULATION	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-276	75	351
Garage	EXTERIOR WALL CONTINUOUS INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6/inch, 40, 60, 80, 100, 120, 140, 160, 180, 200 mm	-1,136	1,151	2,287
Garage	LIGHT WOOD FRAME GARAGE PARTITION WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	103	103	0
Garage	GARAGE PARTITION WALL CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	122	122	0
Garage	INTERIOR CLADDING	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	155	155	0
Garage	INTERIOR CLADDING	Drywall 5/8" / USG / EcoSmart Firecode / 5/8"	76	76	0
Garage	INTERIOR CLADDING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	102	102	0
Garage	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	282	282	0
Garage	EXTERIOR WALL CLADDING	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	163	163	0
Garage	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Fiberglass frame / BHCA Study [US & CA]	103	103	0
Garage	CEILING FINISHES	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	63	63	0
Garage	ROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, KO, Johns Mansville, Malarkey, Siplast, Soprema /	25	25	0
Garage	CONTINUOUS ROOF INSULATION	Wood fiber board / GUTEX / Multi-Therm / R 3.6/inch, 40, 60, 80, 100, 120, 140, 160, 180, 200 mm	-75	76	152
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / CrossLam / 3-1/2"	61	61	0
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / CrossLam / 3-1/2"	1,474	1,474	0
Garage	ADDITIONAL MATERIALS	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-424	116	540

Van 03 High MCI Best possible materials

REVIEW PROJECT MATERIALS			5,367	115,215	109,848
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONCRETE SLABS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	5,654	5,654	0
Footings & Slabs	EARTHEN FLOOR SYSTEMS	Earthen Floor / Cast-in-place / Clay, sand, and straw / 4" (100 mm) RJS	127	666	538
Footings & Slabs	REBAR FOR SLABS	Rebar / Nucor Corporation / 20M	2,079	2,079	0
Footings & Slabs	SUB-SLAB INSULATION	Foam glass aggregate / Hasopor / R 1.7/inch, 10-60 mm [EU]	1,242	1,242	0
Footings & Slabs	ADDITIONAL MATERIALS	Foam glass aggregate / Glasopor AS / R 1.7/inch, 10-60 mm [EU]	151	151	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete - 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	2,590	2,590	0
Footings & Slabs	ADDITIONAL MATERIALS	Concrete - 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	3,823	3,823	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	6,064	6,064	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Nucor Corporation / 15M	4,487	4,487	0
Foundation Walls	CONTINUOUS INSULATION	Cork board insulation / Amorim / Isolamentos / R4/inch	-4,233	1,844	6,078
Foundation Walls	INTERIOR WALL CLADDING	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-423	737	1,159
Foundation Walls	ADDITIONAL MATERIALS	Cork board insulation / Amorim / Isolamentos / R4/inch	-2,883	1,256	4,138
Foundation Walls	ADDITIONAL MATERIALS	Cork board insulation / Amorim / Isolamentos / R4/inch	-1,281	558	1,839
Foundation Walls	ADDITIONAL MATERIALS	Concrete - 0.25 MPa, Canadian Benchmark Average / CRMCA [Industry Avg CA]	136	136	0
Structural Elements	STRUCTURAL TIMBER	Glued Laminated Timber (Glulam) / AWC & CWC [Industry Avg US & CA]	796	796	0
Structural Elements	STRUCTURAL STEEL - WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W250x67 (US W10x45) / AISC [Industry Avg US]	490	490	0
Structural Elements	STRUCTURAL STEEL - WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W360x45 (US W14x22) / AISC [Industry Avg US]	748	748	0
Structural Elements	STRUCTURAL STEEL - WIDE FLANGE BEAMS	Structural Steel / Wide Flange / W410x74 (US W16x50) / AISC [Industry Avg US]	1,185	1,185	0
Structural Elements	STRUCTURAL STEEL - OTHER SECTION SHAPES	Structural Steel / Square HSS / 4 x 4 x 1/4" AISC [Industry Avg US]	5,005	5,005	0
Structural Elements	STRUCTURAL STEEL - OTHER SECTION SHAPES	Structural Steel / Square HSS / 5 x 5 x 1/4" AISC [Industry Avg US]	1,884	1,884	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	91	91	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	427	427	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	1,444	1,444	0
Exterior Walls	CAVITY INSULATION	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-4,246	533	4,778
Exterior Walls	CONTINUOUS INSULATION	Wood fiber board / R 2.7/inch / NAFA [Industry Avg US & CA]	-13,819	14,244	28,064
Exterior Walls	ADDITIONAL MATERIALS	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-784	98	883
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Bamboo Cladding / Dusso / dussoXTR Bamboo RainClad® Siding / Shiplap, 3/4" (19 mm)	-2,312	7,924	10,236
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-781	1,361	2,142
Exterior Wall Cladding	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	268	268	0
Exterior Wall Cladding	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	58	58	0
Windows	WINDOWS - DOUBLE-GLAZED	Window - double glazed / Fiberglass frame / BICA Study [US & CA]	11,867	11,867	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg US & CA]	33	33	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	463	463	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	86	86	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-1,144	1,993	3,137
Interior Walls	ADDITIONAL MATERIALS	Wood / SPF / 3/4" boards / AWC & CWC [Industry Avg US & CA]	61	61	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	437	437	0
Interior Walls	ADDITIONAL MATERIALS	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	105	105	0
Floors	LAMINATED TIMBER FLOOR PANELS	Cross Laminated Timber / Structurlam / CrossLam / 3-1/2"	4,461	4,461	0
Floors	FLOORING	Hard Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 13mm (1/2"), High Density	-1,013	1,205	2,218
Floors	ADDITIONAL MATERIALS	Earthen Floor / Cast-in-place / Clay, sand, and straw / 4" (100 mm) RJS	14	73	59
Floors	ADDITIONAL MATERIALS	Hempcrete / Cast in-situ / USA / R 2.1/inch, Avg. mix using NH-L & PH-L	-148	437	585
Floors	ADDITIONAL MATERIALS	Hempcrete / Cast in-situ / USA / R 2.1/inch, Avg. mix using NH-L & PH-L	-203	599	802
Floors	ADDITIONAL MATERIALS	Cork board insulation / Amorim / Isolamentos / R4/inch	-313	136	449
Ceilings	CEILING FINISHES	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-876	1,527	2,403



REVIEW PROJECT MATERIALS

5,367

115,215

109,848

SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Roof	WOOD ROOF FRAMING	Wood joist / TJI 230/360 / 14" Depth / AWC & CWC [Industry Avg US & CA]	784	784	0
Roof	ROOF DECKING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	877	877	0
Roof	WATERPROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, IKO, Johns Mansville, Malarkey, Siplast, Soprema /	1,407	1,407	0
Roof	ROOF CAVITY INSULATION	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-6,348	797	7,145
Roof	CONTINUOUS ROOF INSULATION	Wood fiber board / R 2.7/inch / NAFA [Industry Avg US & CA]	-9,921	10,226	20,147
Garage	GARAGE SLAB FLOOR	Concrete - 31-35 MPa, 6-14% FA/SL, GU / CRMCA [Industry Avg CA]	605	605	0
Garage	REINFORCING MESH FOR GARAGE SLAB	Welded wire mesh / Serlas / 6" x 6" x 6/6g / Norway	69	69	0
Garage	LIGHT WOOD FRAME EXTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	95	95	0
Garage	EXTERIOR WALL CAVITY INSULATION	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-830	104	934
Garage	EXTERIOR WALL CONTINUOUS INSULATION	Wood fiber board / R 2.7/inch / NAFA [Industry Avg US & CA]	-2,702	2,785	5,488
Garage	LIGHT WOOD FRAME GARAGE PARTITION WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	103	103	0
Garage	GARAGE PARTITION WALL CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	122	122	0
Garage	INTERIOR CLADDING	Lime/Cork Plaster / Daisen / Diathonite Evolution / Plaster, 3/4"	-213	372	585
Garage	STRUCTURAL SHEATHING	Plywood / 3/4" / AWC & CWC [Industry Avg US & CA]	282	282	0
Garage	EXTERIOR WALL CLADDING	Bamboo Cladding / Dasso / dassoXTR Bamboo RainClad® Siding / Shiplap, 3/4" (19 mm)	-904	3,099	4,003
Garage	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Fiberglass frame / BICA Study [US & CA]	103	103	0
Garage	CEILING FINISHES	Lime/Cork Plaster / Daisen / Diathonite Evolution / Plaster, 3/4"	-86	150	236
Garage	ROOFING MEMBRANE	SBS Modified Bitumen Roofing / ARMA / Includes: CertainTeed, Firestone, GAF, Henry, IKO, Johns Mansville, Malarkey, Siplast, Soprema /	25	25	0
Garage	CONTINUOUS ROOF INSULATION	Wood fiber board / R 2.7/inch / NAFA [Industry Avg US & CA]	-180	185	365
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / CrossLam / 3-1/2"	61	61	0
Garage	ADDITIONAL MATERIALS	Cross Laminated Timber / Structurlam / CrossLam / 3-1/2"	1,474	1,474	0
Garage	ADDITIONAL MATERIALS	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-1,276	160	1,436

Appendix B

Van 06 Low MCI As built

REVIEW PROJECT MATERIALS			10,466	10,466	0
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 0.25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	1,005	1,005	0
Footings & Slabs	CONCRETE SLABS	Concrete - 0.25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	1,750	1,750	0
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 10M	49	49	0
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	71	71	0
Footings & Slabs	SUB-SLAB INSULATION	EPS foam board / R 4.0/inch avg [BEAM Avg US & CA]	434	434	0
Footings & Slabs	BASEMENT FLOORING	Hardwood flooring / mafi / Natural Hardwood Planks / 3/4", 3 ply laminated solid, oil pre-finished	529	529	0
Footings & Slabs	AGGREGATE BASE	Aggregate / US Average [Industry Avg]	70	70	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 0.25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	940	940	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 10M	74	74	0
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / R 5.0/inch [BEAM Avg US & CA]	363	363	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	302	302	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	329	329	0
Exterior Walls	CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	391	391	0
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Cedar Siding / Western Red Cedar Lumber Assn / 1x6 Boards [Industry Avg CA]	203	203	0
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x2 Lumber / AWC & CWC [Industry Avg US & CA]	13	13	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 1/2" [BEAM Avg US & CA]	287	287	0
Windows	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Vinyl frame / BICA Study [US & CA]	1,558	1,558	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	10	10	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	81	81	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" [BEAM Avg US & CA]	343	343	0
Floors	LIGHT WOOD FLOOR FRAMING	Wood joist / TJI 230/360 / 9-1/2" Depth / AWC & CWC [Industry Avg US & CA]	125	125	0
Floors	SUB FLOORING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	72	72	0
Floors	FLOORING	Hardwood flooring / mafi / Natural Hardwood Planks / 3/4", 3 ply laminated solid, oil pre-finished	364	364	0
Floors	FLOOR CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	14	14	0
Ceilings	CEILING FINISHES	Drywall 1/2" [BEAM Avg US & CA]	205	205	0
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	257	257	0
Roof	ROOFING	Asphalt Shingles [Industry Avg US & CA]	296	296	0
Roof	ROOF CAVITY INSULATION	Fiberglass batt / R 3.6/inch [BEAM Avg]	192	192	0
Roof	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	140	140	0

Van 06 Low MCI Best available materials

REVIEW PROJECT MATERIALS			3,329	10,097	6,768
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	603	603	0
Footings & Slabs	CONCRETE SLABS	Concrete - 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	1,050	1,050	0
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Nucor Corporation / 10M	43	43	0
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire mesh / Serfas / 6" x 6" x 6g / Norway	71	71	0
Footings & Slabs	SUB-SLAB INSULATION	EPS foam board with graphite / BASF / Neopor / R 4.7/inch, Type IX	311	311	0
Footings & Slabs	BASEMENT FLOORING	Laminated Bamboo flooring / MOSO / Bamboo Elite, PureBamboo / 15mm (9/16")	-271	329	600
Footings & Slabs	AGGREGATE BASE	Aggregate / Martin Marietta / Avg construction aggregate (gravel & sand)	19	19	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	564	564	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Nucor Corporation / 10M	65	65	0
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / SOPREMA / SOPRA-XPS / R 5.0/inch	71	71	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg US & CA]	302	302	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	329	329	0
Exterior Walls	CAVITY INSULATION	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-1,038	283	1,321
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Bamboo Cladding / Dasso / dassoXTR Bamboo RainClad® Siding / Shiplap, 3/4" (19 mm)	-789	2,705	3,494
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x2 Lumber / AWC & CWC [Industry Avg US & CA]	13	13	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	175	175	0
Windows	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Vinyl frame / BICA Study [US & CA]	1,558	1,558	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	10	10	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	81	81	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	209	209	0
Floors	LIGHT WOOD FLOOR FRAMING	Wood / joist / TJI 230/360 / 9-1/2" Depth / AWC & CWC [Industry Avg US & CA]	125	125	0
Floors	SUB FLOORING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	72	72	0
Floors	FLOORING	Laminated Bamboo flooring / MOSO / Bamboo Elite, PureBamboo / 15mm (9/16")	-186	226	412
Floors	FLOOR CAVITY INSULATION	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-229	62	291
Ceilings	CEILING FINISHES	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	125	125	0
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	257	257	0
Roof	ROOFING	Asphalt Shingles / Owens Corning / Supreme /	160	160	0
Roof	ROOF CAVITY INSULATION	Cellulose / batt / CMS / EcoCell / R 3.6/inch	-510	139	649
Roof	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	140	140	0

Van 06 Low MCI Best possible materials

REVIEW PROJECT MATERIALS			-3,212	10,590	13,802
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	452	452	0
Footings & Slabs	EARTHEN FLOOR SYSTEMS	Earthen Floor / Cast-in-place / Clay, sand, and straw / 4" (100 mm) [US]	28	148	120
Footings & Slabs	SUB-SLAB INSULATION	Foam glass aggregate / Hascopor / R 1.7/inch, 10-60 mm [EU]	56	56	0
Footings & Slabs	BASEMENT FLOORING	Laminated Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 15mm (9/16")	-271	329	600
Footings & Slabs	AGGREGATE BASE	Aggregate / Martin Marietta / Avg construction aggregate (gravel & sand)	19	19	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	423	423	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Nucor Corporation / 10M	65	65	0
Foundation Walls	CONTINUOUS INSULATION	Cork board insulation / Amorim / Isolamentos / R4/inch	-253	110	363
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x8 Lumber / AWC & CWC [Industry Avg US & CA]	302	302	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	329	329	0
Exterior Walls	CAVITY INSULATION	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-3,121	392	3,513
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Bamboo Cladding / Dasso / dassoXTR Bamboo RainClad® Siding / Shiplap, 3/4" (19 mm)	-789	2,705	3,494
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x2 Lumber / AWC & CWC [Industry Avg US & CA]	13	13	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-241	420	661
Windows	WINDOWS - DOUBLE-GLAZED	Window - double glazed / Vinyl frame / BICA Study [US & CA]	1,558	1,558	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	10	10	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	81	81	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-288	502	790
Floors	LIGHT WOOD FLOOR FRAMING	Wood joist / TJI 230/360 / 9-1/2" Depth / AWC & CWC [Industry Avg US & CA]	125	125	0
Floors	SUB FLOORING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	72	72	0
Floors	FLOORING	Hard Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 13mm (1/2"), High Density	-248	295	543
Floors	FLOOR CAVITY INSULATION	Hempcrete / Cast in-situ / USA / R 2.1/inch, Avg. mix using NHL & PHL	-385	1,136	1,521
Ceilings	CEILING FINISHES	Lime/Cork Plaster / Diasen / Diathonite Evolution / Plaster, 3/4"	-172	299	471
Roof	WOOD ROOF FRAMING	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWED [Industry Avg CA]	257	257	0
Roof	ROOFING	Asphalt Shingles / Owens Corning / Supreme /	160	160	0
Roof	ROOF CAVITY INSULATION	Straw Bale / Wheat & barley straw / SNaB (UK) / R 2.8/inch	-1,534	193	1,727
Roof	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	140	140	0

Appendix C

Van 02 Average MCI As built

REVIEW PROJECT MATERIALS			31,493	31,578	86
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	2,089	2,089	0
Footings & Slabs	CONCRETE SLABS	Concrete - 0.25 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	1,702	1,702	0
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	224	224	0
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	86	86	0
Footings & Slabs	SUB-SLAB INSULATION	Mineral wool board - heavy density / NA/MA / R 4.2/inch [Industry Avg N.America]	1,127	1,127	0
Footings & Slabs	BASEMENT FLOORING	Hardwood flooring / CRAFT Artisan Wood Floors / Engineered / 5/8", SFI Certified	805	805	0
Footings & Slabs	AGGREGATE BASE	Aggregate / US Average [Industry Avg]	128	128	0
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete - 26-30 MPa, 0.14% FA/SL, GU / CRMCA [Industry Avg CA]	5,000	5,000	0
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 10M	261	261	0
Foundation Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	54	54	0
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / R 5.0/inch [BEAM Avg US & CA]	590	590	0
Foundation Walls	CAVITY INSULATION	Mineral wool batt / [BEAM Avg]	160	160	0
Foundation Walls	INTERIOR WALL CLADDING	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	114	114	0
Structural Elements	STRUCTURAL TIMBER	Laminated veneer lumber (LVL) / AWC & CWC [Industry Avg US & CA]	771	771	0
Structural Elements	STRUCTURAL TIMBER	Wood / SPF / Lumber by volume / AWC & CWC [Industry Avg US & CA]	194	194	0
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	305	305	0
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 5/8" / AWC & CWC [Industry Avg US & CA]	482	482	0
Exterior Walls	CAVITY INSULATION	Mineral wool batt / [BEAM Avg]	908	908	0
Exterior Walls	CONTINUOUS INSULATION	Mineral wool board - light density / NA/MA / R 3.7/inch [Industry Avg N.America]	1,947	1,947	0
Party Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	164	164	0
Party Walls	CAVITY INSULATION	Mineral wool batt / [BEAM Avg]	488	488	0
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	697	697	0
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Brick, Clay / Interstate / Avg Face Brick / 3.5/8" x 2.3/4" x 7.5/8" (92 x 76 x 194 mm) incl. 3/8" mortar	197	197	0
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePanel / 8 mm	872	927	55
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePlank / 8 mm	207	223	16
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	36	36	0
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	412	412	0
Windows	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Vinyl frame / BICA Study [US & CA]	1,875	1,875	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	79	79	0
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	82	82	0
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" [BEAM Avg US & CA]	458	458	0
Floors	LIGHT WOOD FLOOR FRAMING	Wood / joist / TJI 230/360 / 11-7/8" Depth / AWC & CWC [Industry Avg US & CA]	568	568	0
Floors	LIGHT WOOD FLOOR FRAMING	Wood / SPF / 2x10 Lumber / AWC & CWC [Industry Avg US & CA]	25	25	0
Floors	SUB FLOORING	OSB sheathing / 5/8" / AWC & CWC [Industry Avg US & CA]	461	461	0
Floors	FLOORING	Hardwood flooring / CRAFT Artisan Wood Floors / Engineered / 5/8", SFI Certified	1,845	1,845	0
Floors	FLOOR CAVITY INSULATION	Spray polyurethane foam - Closed Cell (HFC gas) / R 6.6/inch / SPFA [Industry Avg US & CA]	855	855	0
Floors	ADDITIONAL MATERIALS	Mineral wool batt / [BEAM Avg]	288	288	0
Floors	ADDITIONAL MATERIALS	Mineral wool batt / [BEAM Avg]	94	94	0
Ceilings	CEILING FINISHES	Drywall 1/2" [BEAM Avg US & CA]	217	217	0
Ceilings	CEILING FINISHES	Drywall 5/8" Type X / Gypsum Association [Industry Avg US & CA]	344	344	0
Roof	WOOD ROOF FRAMING	Wood / SPF / 2x12 Lumber / AWC & CWC [Industry Avg US & CA]	103	103	0
Roof	ROOF DECKING	Plywood / 5/8" / AWC & CWC [Industry Avg US & CA]	212	212	0
Roof	ROOF STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	16	16	0
Roof	ROOFING	Asphalt Shingles [Industry Avg US & CA]	310	310	0
Roof	ROOF CAVITY INSULATION	Mineral wool batt / [BEAM Avg]	369	369	0

REVIEW PROJECT MATERIALS			31,493	31,578	86
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Garage	CONTINUOUS FOOTINGS	Concrete – 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	471	471	0
Garage	CONCRETE COLUMN FOOTINGS, PADS & PIERS	Concrete – 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	192	192	0
Garage	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	103	103	0
Garage	REBAR FOR COLUMN FOOTINGS, PADS & PIERS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	51	51	0
Garage	GARAGE AGGREGATE BASE	Aggregate / US Average [Industry Avg]	43	43	0
Garage	GARAGE SLAB FLOOR	Concrete – 31-35 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	929	929	0
Garage	REINFORCING MESH FOR GARAGE SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	57	57	0
Garage	CONCRETE FOUNDATION WALLS	Concrete – 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	251	251	0
Garage	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	105	105	0
Garage	LIGHT WOOD FRAME EXTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	45	45	0
Garage	INTERIOR CLADDING	Drywall 1/2" [BEAM Avg US & CA]	90	90	0
Garage	STRUCTURAL SHEATHING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	77	77	0
Garage	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePanel / 8 mm	231	246	15
Garage	RAIN SCREEN STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	7	7	0
Garage	WINDOWS – DOUBLE-GLAZED	Window – double glazed / Vinyl frame / BICA Study [US & CA]	95	95	0
Garage	CEILING FINISHES	Drywall 1/2" [BEAM Avg US & CA]	43	43	0
Garage	WOOD FRAME CONSTRUCTION	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	77	77	0
Garage	ROOF STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	5	5	0
Garage	ROOFING	Metal Panels - Aluminum / 22 gauge / Metal Construction Assn. [Industry Avg US]	347	347	0
Garage	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	52	52	0

Van 02 Average MCI getting to 120 kg

BEAM BUILDERS FOR CLIMATE ACTION			REVIEW PROJECT MATERIALS	18,243	23,952	5,709
SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)	
Footings & Slabs	CONTINUOUS CONCRETE FOOTINGS	Concrete – 0-25 MPa, 0-14% FA/SL, GU / CRMCA [Industry Avg CA]	2,089	2,089	0	
Footings & Slabs	CONCRETE SLABS	Concrete – 0-25 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	1,270	1,270	0	
Footings & Slabs	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Nucor Corporation / 15M	198	198	0	
Footings & Slabs	REINFORCING MESH FOR SLAB	Welded wire mesh / Serfas / 6" x 6" x 6/6g / Norway	86	86	0	
Footings & Slabs	SUB-SLAB INSULATION	Mineral wool board / Rockwool / Comfortboard 80 / R 4.2/inch	561	561	0	
Footings & Slabs	BASEMENT FLOORING	Laminated Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 15mm (9/16")	-375	455	83	
Footings & Slabs	AGGREGATE BASE	Aggregate / US Average [Industry Avg]	128	128	0	
Foundation Walls	CONCRETE FOUNDATION WALLS	Concrete – 26-30 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	3,707	3,707	0	
Foundation Walls	REBAR FOR FOUNDATION WALLS	Rebar / Nucor Corporation / 10M	230	230	0	
Foundation Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	54	54	0	
Foundation Walls	CONTINUOUS INSULATION	XPS foam board / SOPREMA / SOPRA-XPS / R 5.0/inch	232	232	0	
Foundation Walls	CAVITY INSULATION	Cellulose / batt / OMS / EcoCell / R 3.6/inch	-300	82	382	
Foundation Walls	INTERIOR WALL CLADDING	Drywall 5/8" / USG / EcoSmart Firecode / 5/8"	79	79	0	
Structural Elements	STRUCTURAL TIMBER	Laminated veneer lumber (LVL) / AWC & CWC [Industry Avg US & CA]	771	771	0	
Structural Elements	STRUCTURAL TIMBER	Wood / SPF / Lumber by volume / AWC & CWC [Industry Avg US & CA]	194	194	0	
Exterior Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	305	305	0	
Exterior Walls	STRUCTURAL SHEATHING	Plywood / 5/8" / AWC & CWC [Industry Avg US & CA]	482	482	0	
Exterior Walls	CAVITY INSULATION	Cellulose / dense pack / R 3.7/inch / CIMA [Industry Avg US & CA]	-1,139	522	1,661	
Exterior Walls	CONTINUOUS INSULATION	Mineral wool board / Rockwool / Rockboard 60 / R 4.3/inch	1,516	1,516	0	
Party Walls	LIGHT WOOD FRAME WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	164	164	0	
Party Walls	CAVITY INSULATION	Mineral wool batt / Rockwool / ComfortBatt R22 (5.5") / R 4.0/inch	340	340	0	
Party Walls	INTERIOR CLADDING FOR PARTY WALLS	Drywall 5/8" / USG / EcoSmart Firecode / 5/8"	485	485	0	
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Brick, Clay / Interstate / Avg Face Brick / 3-5/8" x 2-3/4" x 7-5/8" (92 x 70 x 194 mm) incl. 3/8" mortar	197	197	0	
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePanel / 8 mm	872	927	55	
Exterior Wall Cladding	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePlank / 8 mm	207	223	16	
Exterior Wall Cladding	STRAPPING / FURRING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	36	36	0	
Exterior Wall Cladding	INTERIOR CLADDING FOR EXTERIOR WALLS	Drywall 5/8" / USG / EcoSmart Firecode / 5/8"	287	287	0	
Windows	WINDOWS – DOUBLE-GLAZED	Window - double glazed / Vinyl frame / BICA Study [US & CA]	1,875	1,875	0	
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x6 Lumber / AWC & CWC [Industry Avg US & CA]	79	79	0	
Interior Walls	LIGHT WOOD FRAME INTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	82	82	0	
Interior Walls	CLADDING FOR INTERIOR WALLS	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	280	280	0	
Floors	LIGHT WOOD FLOOR FRAMING	Wood / joist / TJI 230/360 / 11-7/8" Depth / AWC & CWC [Industry Avg US & CA]	568	568	0	
Floors	LIGHT WOOD FLOOR FRAMING	Wood / SPF / 2x10 Lumber / AWC & CWC [Industry Avg US & CA]	25	25	0	
Floors	SUB FLOORING	OSB sheathing / 5/8" / AWC & CWC [Industry Avg US & CA]	461	461	0	
Floors	FLOORING	Laminated Bamboo flooring / MOSO / Bamboo Elite, Purebamboo / 15mm (9/16")	-859	1,042	1,901	
Floors	FLOOR CAVITY INSULATION	Spray polyurethane foam - Closed Cell (HFO gas) / Huntsman / Heatlok Soya HFO & Heatlok HFO / R 6.5/inch	163	163	0	
Floors	ADDITIONAL MATERIALS	Cellulose / batt / OMS / EcoCell / R 3.6/inch	-303	83	386	
Floors	ADDITIONAL MATERIALS	Cellulose / batt / OMS / EcoCell / R 3.6/inch	-99	27	126	
Ceilings	CEILING FINISHES	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	132	132	0	
Ceilings	CEILING FINISHES	Drywall 5/8" / USG / EcoSmart Firecode / 5/8"	240	240	0	
Roof	WOOD ROOF FRAMING	Wood / SPF / 2x12 Lumber / AWC & CWC [Industry Avg US & CA]	103	103	0	
Roof	ROOF DECKING	Plywood / 5/8" / AWC & CWC [Industry Avg US & CA]	212	212	0	
Roof	ROOF STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	16	16	0	
Roof	ROOFING	Asphalt Shingles / Owens Corning / Supreme /	167	167	0	
Roof	ROOF CAVITY INSULATION	Cellulose / loose fill / R 3.7/inch / CIMA [Industry Avg US & CA]	-231	106	337	



REVIEW PROJECT MATERIALS

18,243

23,952

5,709

SECTION	CATEGORY	MATERIAL	NET EMISSIONS (kg CO ₂ e)	CARBON EMISSIONS (kg CO ₂ e)	CARBON STORAGE (kg CO ₂ e)
Garage	CONTINUOUS FOOTINGS	Concrete - 0-25 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	352	352	0
Garage	CONCRETE COLUMN FOOTINGS, PADS & PIERS	Concrete - 0-25 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	143	143	0
Garage	REBAR FOR CONTINUOUS FOOTINGS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	103	103	0
Garage	REBAR FOR COLUMN FOOTINGS, PADS & PIERS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	51	51	0
Garage	GARAGE AGGREGATE BASE	Aggregate / US Average [Industry Avg]	43	43	0
Garage	GARAGE SLAB FLOOR	Concrete - 31-35 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	684	684	0
Garage	REINFORCING MESH FOR GARAGE SLAB	Welded wire mesh / Serlas / 6" x 6" x 6/6g / Norway	57	57	0
Garage	CONCRETE FOUNDATION WALLS	Concrete - 0-25 MPa, 35-50% Slag, GU / CRMCA [Industry Avg CA]	187	187	0
Garage	REBAR FOR FOUNDATION WALLS	Rebar / Concrete Reinforcing Steel Institute [Industry Avg N.America] / 15M	105	105	0
Garage	LIGHT WOOD FRAME EXTERIOR WALLS	Wood / SPF / 2x4 Lumber / AWC & CWC [Industry Avg US & CA]	45	45	0
Garage	INTERIOR CLADDING	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	41	41	0
Garage	STRUCTURAL SHEATHING	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	77	77	0
Garage	EXTERIOR WALL CLADDING	Fiber Cement Cladding / James Hardie / HardiePanel / 8 mm	231	246	15
Garage	RAIN SCREEN STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	7	7	0
Garage	WINDOWS - DOUBLE-GLAZED	Window - double-glazed / Vinyl frame / BICA Study [US & CA]	95	95	0
Garage	CEILING FINISHES	Drywall 1/2" / CertainTeed / AirRenew / 1/2" (12.7 mm)	26	26	0
Garage	WOOD FRAME CONSTRUCTION	Wood roof truss / Gable Roof, Double Howe, 2x6 Chords, 2x4 Webs, 4:12 Pitch / QWEB [Industry Avg CA]	77	77	0
Garage	ROOF STRAPPING	Wood / SPF / 1x4 Lumber / AWC & CWC [Industry Avg US & CA]	5	5	0
Garage	ROOFING	Metal Panels - Steel / Canadian Sheet Steel Building Institute / 24 gauge [Industry Avg CA]	279	279	0
Garage	ADDITIONAL MATERIALS	Plywood / 1/2" / AWC & CWC [Industry Avg US & CA]	52	52	0