# MATERIAL EMISSIONS BENCHMARK REPORT

## FOR PART 9 HOMES IN

# VANCOUVER

CITY OF VANCOUVER

BUILDERS FOR CLIMATE ACTION

# Authors & Acknowledgements

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| | |
|---|---|
| Nick Bray Architecture | b collective |
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## 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.

# Table of contents

# 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/$m^2$.
- 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/$m^2$.
- The authors recommend that the City of Vancouver use 200 kg CO2e/$m^2$ 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/$m^2$ 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 CO2e | MCI (total floor area) kg $CO2/m^2$ | MCI heated floor area kg $CO2e/m^2$ | MCI per bdrm kg $CO2e/m^2$ /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 CO2e | **MCI** kg CO2e/m2 | **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/$m^2$ of heated floor area, with an average of 193 kg CO2e/$m^2$. 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/$m^2$ 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 Castelgar, BC, were lower than those in both Vancouver and Toronto.

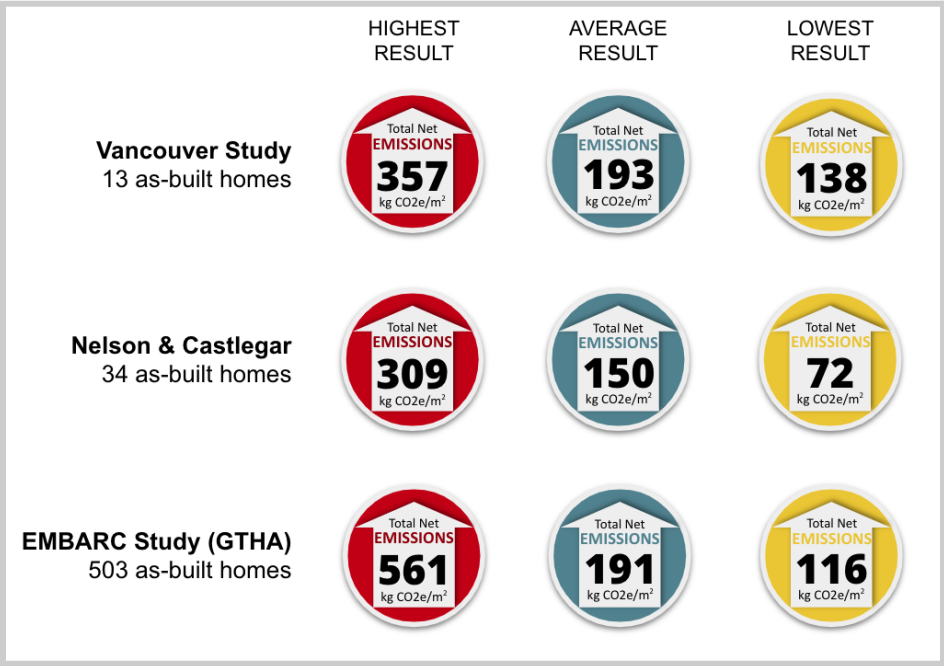



Figure 3.2. MCI results of three studies of new homes in Canada.

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 $CO_2e/m^2$ | MCI per bedroom kg $CO_2e/m^2$/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.

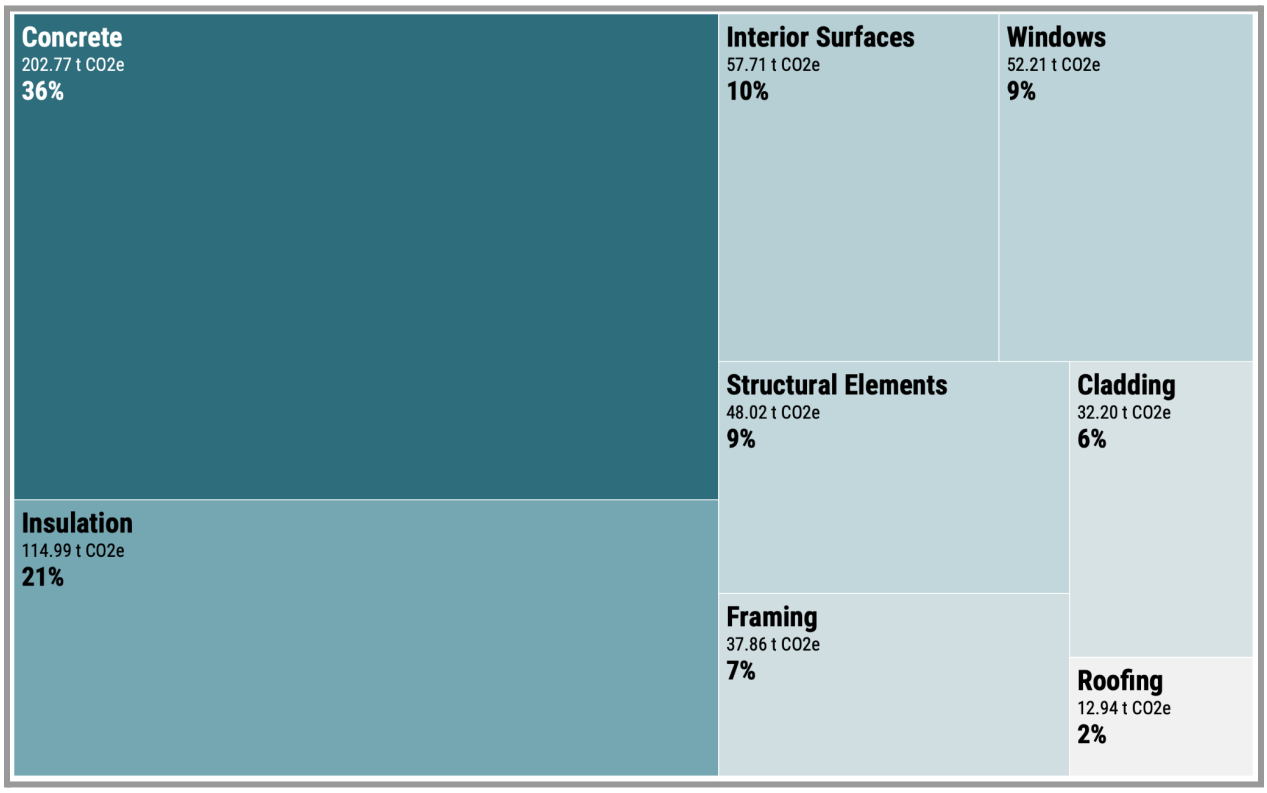



Figure 3.4. Emissions from all houses by material category.

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 CO2e/$m^3$ | **Emissions from all concrete in study** kg CO2e | **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.

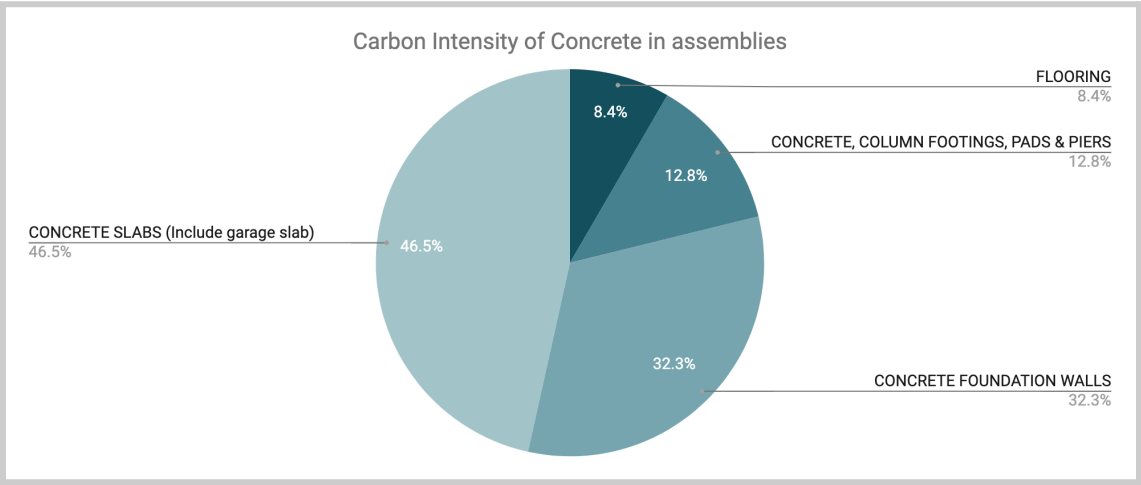



Figure 3.6. Carbon intensity of concrete in different assemblies.

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.

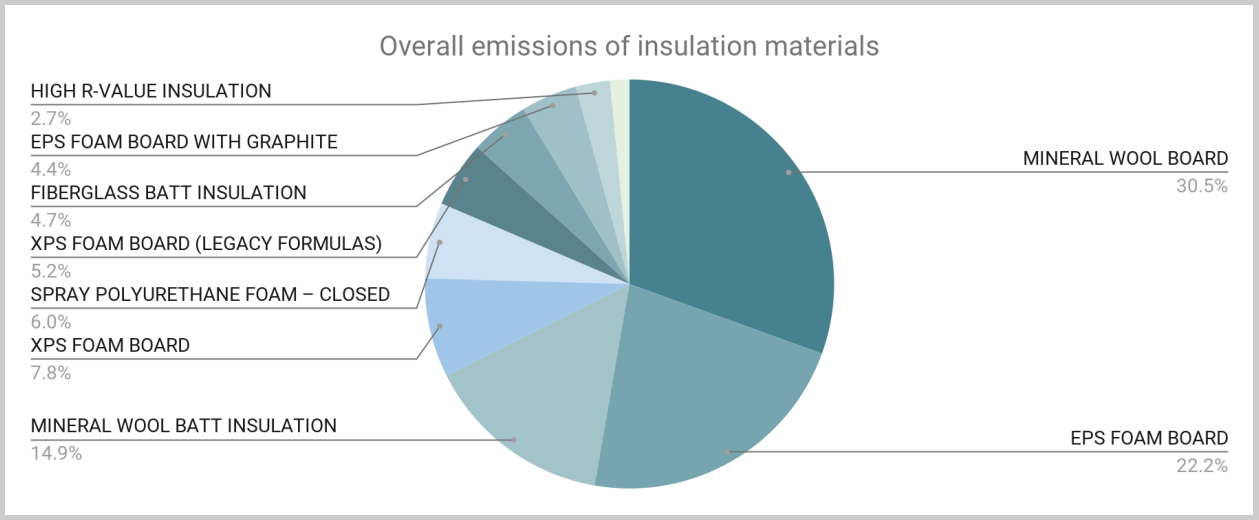



Figure 3.7. Emissions from insulation materials.

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/$m^2$. Hardwood flooring is the next largest emitter in the category at 31 percent and has an emissions intensity of 15.2 kg CO2e/$m^2$. 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/$m^2$ and covers only 128 $m^2$ in the study buildings, compared to 1,176 $m^2$ 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.

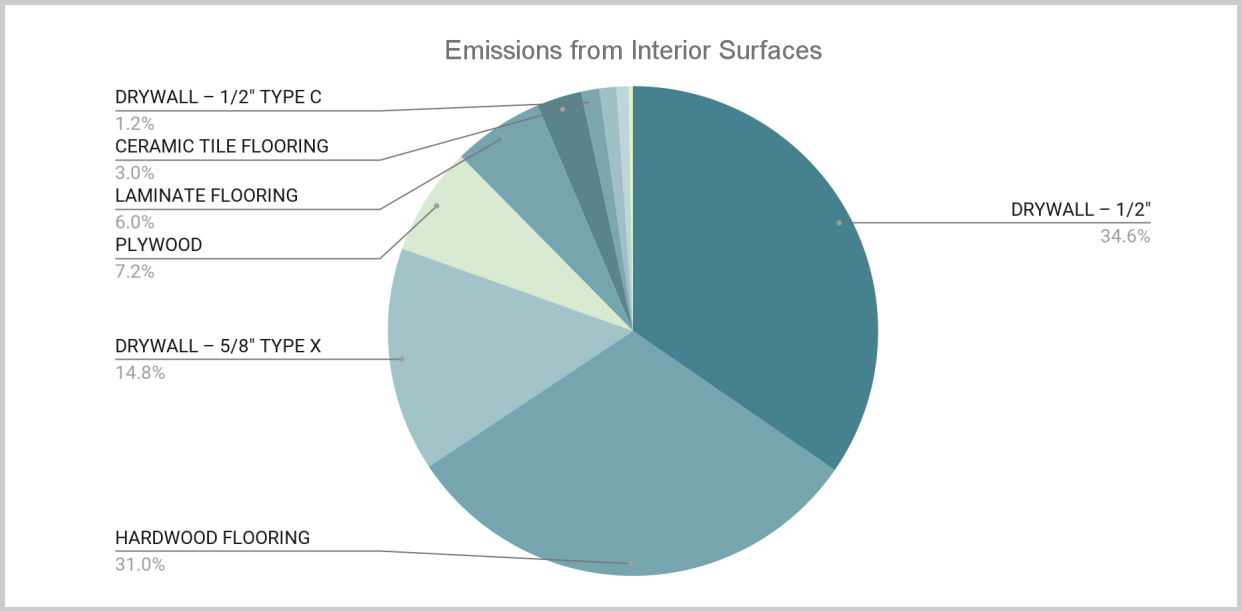



Figure 3.8. Total emissions from all interior surface materials

## 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.

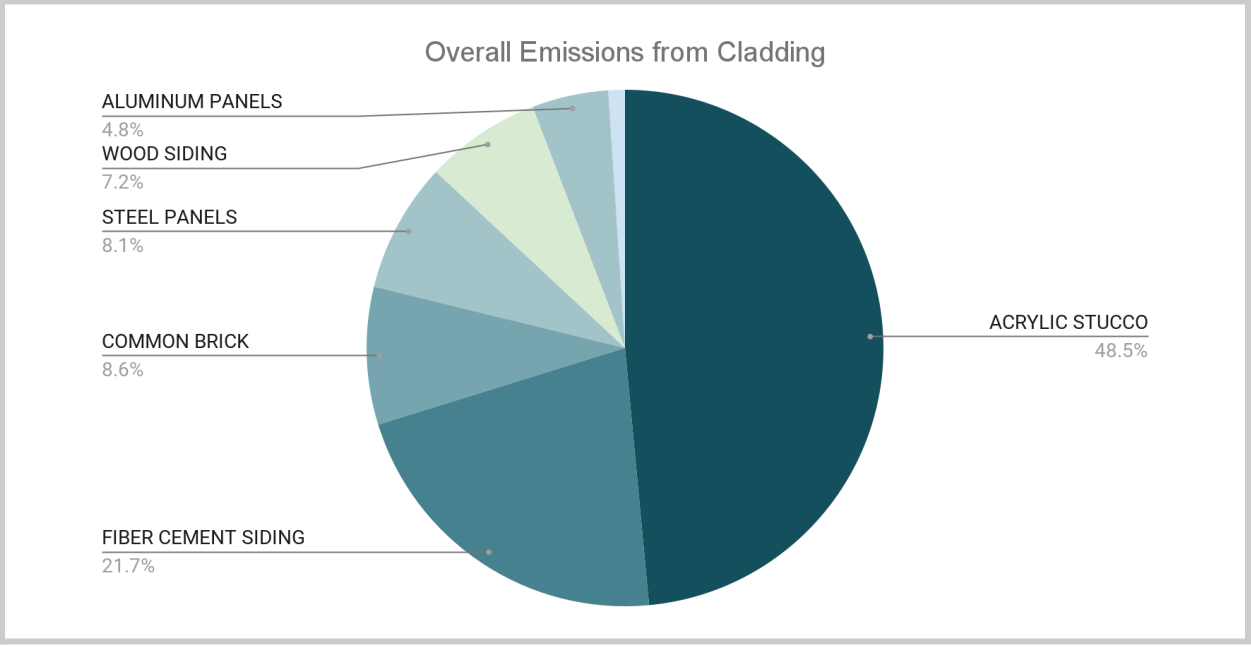



Figure 3.9. Total emissions from all cladding materials

Wood siding, which represents just 7.2 percent of emissions, covers more area at 1,612 $m^2$ than any other material in the category, but has a low emissions intensity of 1 kg $CO2e/m^2$. Acrylic stucco was the largest contributor of emissions in the category, but covers only 476 $m^2$ 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 $CO2e/m^2$ (the second highest result) and 138 kg $CO2e/m^2$ (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:

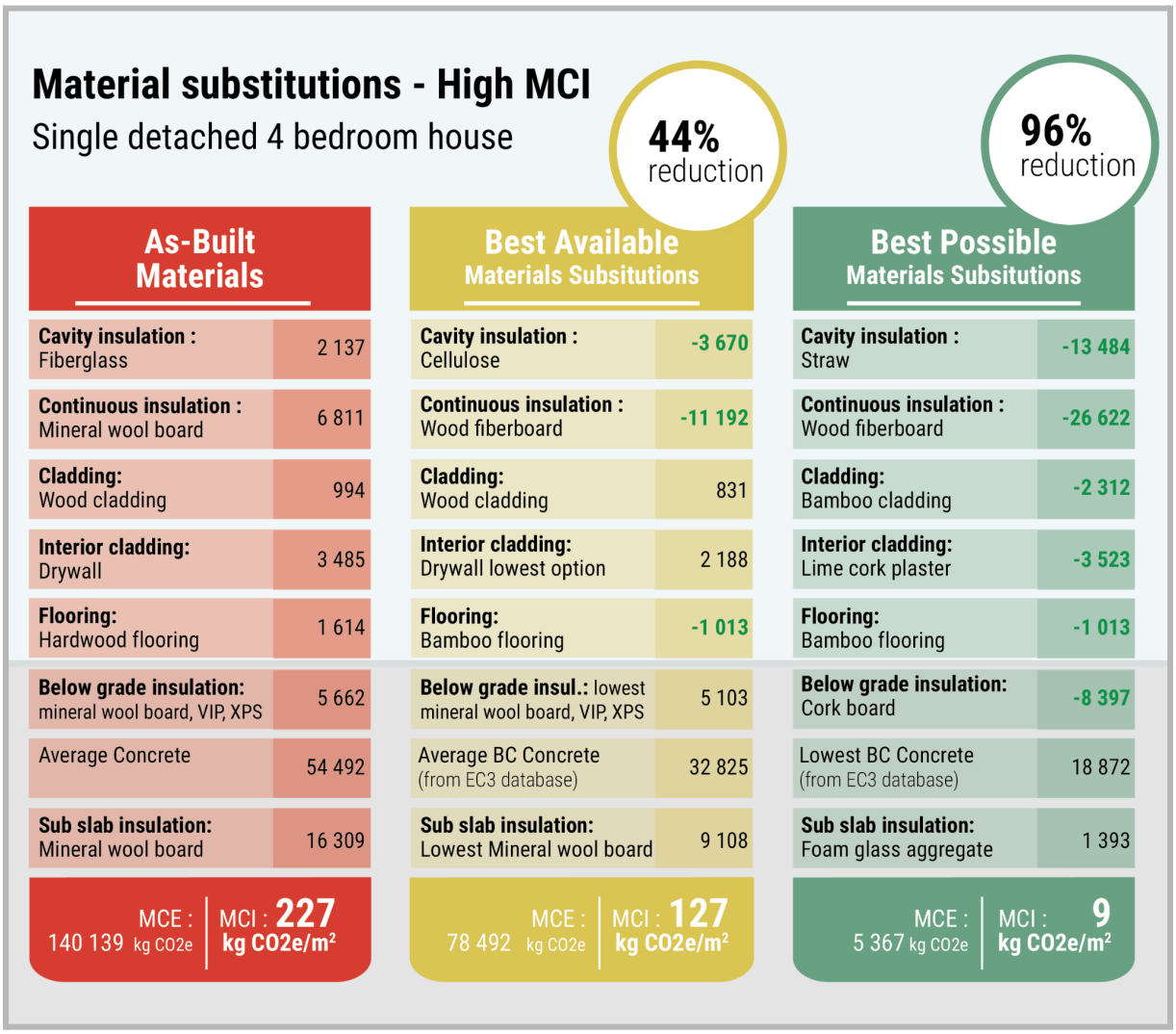
- Concrete with emissions at average of all BC concrete EPDs from EC3 database
- Cellulose insulation replaces other cavity insulation
- Wood fiberboard insulation replaces other above-grade vertical board insulation
- Bamboo flooring replaces hardwood flooring
- Where possible, best-in-category materials 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.

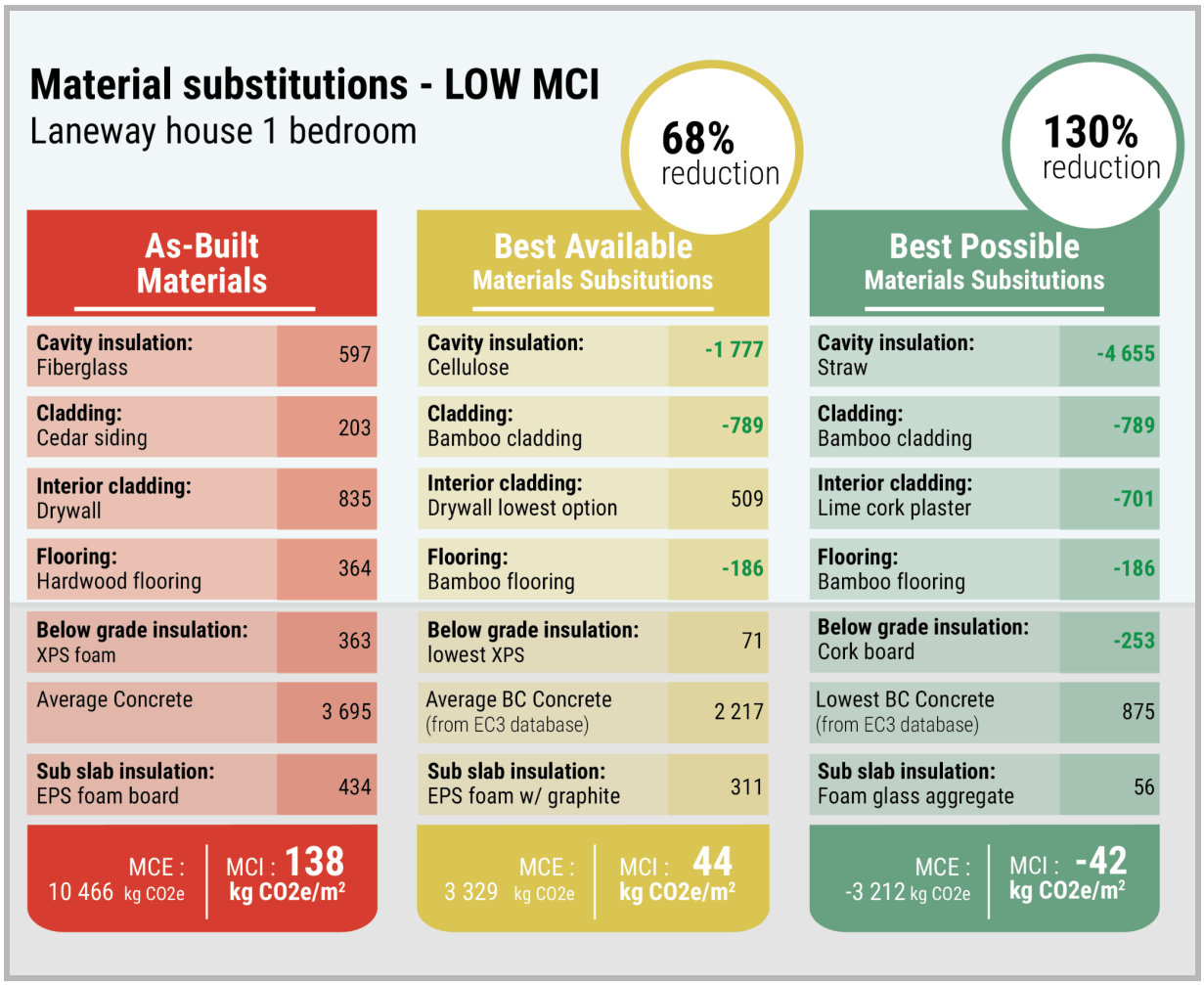



Illustration 3.10. Results of material substitutions on material emissions

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 $m^2$ with an additional suite and detached garage was chosen because the as-built MCI of 191 kg $CO2e/m^2$ was close to the average of 193. Material substitutions were made to reduce the MCI of the house close to 120 kg $CO2e/m^2$ which would represent a 40 percent reduction in material emissions.

Only four types of substitution were need to achieve MCI of 110 kg CO2e/$m^2$, just below the 40 percent reduction target:

- Concrete changed to the best Canadian average result (214 kg CO2/$m^3$). 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 CO2 e) | **Annual operational emissions** (t CO2 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 CO2 e) | **Annual operational emissions** (t CO2 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 CO2e | MCI kg CO2e/m2 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 ⅝-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/$m^2$, 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/m$^2$.** Based on the average net MCI in this study of 193 kg CO2e/m$^2$, it is recommended that the City of Vancouver use a rounded baseline of 200 kg CO2e/m$^2$ 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/m$^2$ would mean the city’s intended 40 percent reduction by 2030 would bring MCI down to 120 kg CO2e/m$^2$. 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/m$^2$ 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/m$^2$, 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/m$^2$). 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

| BEAM / CLIMATE ACTION | | REVIEW PROJECT MATERIALS | 140,139 | 140,139 | 0 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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] / 15M | 5,091 | 5,091 | 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" [BEAM Avg \| US & CA] | 504 | 504 | 0 |
| Foundation Walls | ADDITIONAL MATERIALS | Vacuum Insulated Panel / Porextherm / Vacupor / 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 / 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 | Fiberglass batt / R 3.6/inch [BEAM Avg] | 468 | 468 | 0 |
| Exterior Walls | CONTINUOUS INSULATION | Mineral wool board / Rockwool / Rockboard 60 / 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 / BTCA 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 / Structurlam / 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 60 / 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 / TJI 230/360 / 14" Depth / AWC & CWC [Industry Avg \| US & CA] | 784 | 784 | 0 |

| BEAM | BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | 140,139 | 140,139 | 0 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 | Fiberglass loose fill / ~R2.6/inch [BEAM Avg] | 1,185 | 1,185 | 0 |
| Roof | CONTINUOUS ROOF INSULATION | Mineral wool board / Rockwool / Rockboard 60 / 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 60 / 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 / BfCA 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, IKO, Johns Mansville, Malarkey, Siplast, Soprema / | 25 | 25 | 0 |
| Garage | CONTINUOUS ROOF INSULATION | Mineral wool board / Rockwool / Rockboard 60 / 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

| BEAM | BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | 78,492 | 108,146 | 29,654 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 / Porextherm / Vacupor / 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 / BfCA 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 | 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 | 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 / TJI 230/360 / 14" Depth / AWC & CWC [Industry Avg \| US & CA] | 784 | 784 | 0 |

| BEAM | BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | 78,492 | 108,146 | 29,654 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 | 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 / BfCA 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, IKO, 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

| BEAM / BUILDERS FOR CLIMATE ACTION | | REVIEW PROJECT MATERIALS | 5,367 | 115,215 | 109,848 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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) [US] | 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 / Dasso / dassoXTR 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 / BTCA 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) [US] | 14 | 73 | 59 |
| Floors | ADDITIONAL MATERIALS | Hemporete / Cast in-situ / USA / R 2.1/inch, Avg. mix using NHL & PHL | -148 | 437 | 585 |
| Floors | ADDITIONAL MATERIALS | Hemporete / Cast in-situ / USA / R 2.1/inch, Avg. mix using NHL & PHL | -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 |

| BEAM | BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | 5,367 | 115,215 | 109,848 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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, 0-14% FA/SL, GU / CRMCA [Industry Avg \| CA] | 605 | 605 | 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 | 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 / Diasen / 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 / BfCA Study [US & CA] | 103 | 103 | 0 |
| Garage | CEILING FINISHES | Lime/Cork Plaster / Diasen / 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

| BEAM / CLIMATE ACTION | REVIEW PROJECT MATERIALS | 10,466 | 10,466 | 0 |
|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 / 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 | 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 / BfCA 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 I 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

| BEAM | BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | 3,329 | 10,097 | 6,768 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 6/6g / 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 / BTCA 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 I 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

| BEAM / BUILDERS FOR CLIMATE ACTION | REVIEW PROJECT MATERIALS | | -3,212 | 10,590 | 13,802 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 / Hasopor / 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 / BfCA 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 I 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 / QWEB [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

| BEAM | CLIMATE ACTION | 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 / NAIMA / 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 / NAIMA / 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 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" Type X / Gypsum Association [Industry Avg \| US & CA] | 412 | 412 | 0 |
| Windows | WINDOWS – DOUBLE-GLAZED | Window - double-glazed / Vinyl frame / BfCA 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 I 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 |

| BEAM | CLIMATE ACTION | REVIEW PROJECT MATERIALS | 31,493 | 31,578 | 86 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 / BTCA 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 / CLIMATE ACTION | | REVIEW PROJECT MATERIALS | 18,243 | 23,952 | 5,709 |
|---|---|---|---|---|---|
| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
| 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 | 830 |
| 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 / CMS / 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 / BfCA 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 I-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 / CMS / EcoCell / R 3.6/inch | -303 | 83 | 386 |
| Floors | ADDITIONAL MATERIALS | Cellulose / batt / CMS / 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 |

BEAM | BUILDERS FOR CLIMATE ACTION

**REVIEW PROJECT MATERIALS** | **18,243** | **23,952** | **5,709**

| SECTION | CATEGORY | MATERIAL | NET EMISSIONS (kg $CO_2e$) | CARBON EMISSIONS (kg $CO_2e$) | CARBON STORAGE (kg $CO_2e$) |
|---|---|---|---|---|---|
| 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 / Serfas / 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 / BTCA 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 |