Whole-House Embodied Carbon & Emissions Comparison

This analysis compares whole-house modelling scenarios, each built around a different above-grade wall assembly. This was completed to show how wall choice affects embodied carbon, operational emissions, and total lifecycle emissions over a 30-year period.

Comparison Framework

Scenarios are grouped into two sets, each measured against its own baseline:

- New construction scenarios (baseline: BAU @ACH367): a standard new-build wall improved through tighter air sealing or an alternative insulation strategy.
- Retrofit scenarios (baseline: 2x4 base case): upgrades applied to an existing home.

Each scenario is evaluated with MCE2 modelling software on:

- Operational emissions (tCO2e over 30 years): emissions from heating, cooling, and energy use.
- Materials (embodied) emissions (tCO2e): Greenhouse Gas Emissions (GHGs) from producing and installing materials.
- Biogenic carbon storage (tCO2e): carbon stored in bio-based materials.
- 30-year total emissions (tCO2e): operational plus embodied emissions combined.
- Embodied portion of total (%): embodied emissions as a share of the 30-year total.
- Change vs. baseline: operational emissions change and net emissions difference, relative to each scenario's baseline.

Scenario Performance Data

New Construction Scenarios (baseline: BAU@ACH367)

Scenario	Operational Emissions (tCO2e/30yr)	Materials Emissions (tCO2e)	Biogenic Storage (tCO2e)	30-Year Total (tCO2e)	Embodied Portion (%)	Change in Operational Emissions (tCO2e)	Net Difference vs. Baseline (%)
BAU @ACH367 (baseline)	193	22.8	28.9	215.8	10.6%	—	—
BAU @ACH150	178	22.8	28.9	200.8	11.4%	-15	-7.0%
Ext XPS	154	27.7	32.3	181.7	15.2%	-39	-15.8%
Ext WO (Exterior Mineral Wool)	163	24.5	32.3	187.5	13.1%	-30	-13.1%
DS (Double Stud)	174	25.2	34.6	199.2	12.7%	-19	-7.7%
Fire (Fire Resistant Assembly)	161	24.4	25.9	185.4	13.2%	-32	-14.1%
Larsen (Larsen Truss)	156	23.4	30.6	179.4	13.0%	-37	-16.9%

Retrofit Scenarios (baseline: 2x4 base case)

Scenario	Operational Emissions (tCO2e/30yr)	Materials Emissions (tCO2e)	Biogenic Storage (tCO2e)	30-Year Total (tCO2e)	Embodied Portion (%)	Change in Operational Emissions (tCO2e)	Net Difference vs. Baseline (%)
2x4 base case (baseline)	196	22.5	25.9	218.5	10.3%	—	—
Fire (Reno)	161	24.4	25.9	185.4	13.2%	-35	-15.1%
Larsen (Reno)	156	23.4	30.6	179.4	13.0%	-40	-17.9%

Note: Fire (Reno) and Larsen (Reno) use the same wall assemblies as Fire and Larsen above, modelled as retrofits onto an existing 2x4 home rather than as new-construction alternatives — hence the identical assembly-level figures but different baseline Comparisons.

Commentary

The embodied carbon of above-grade walls and cladding (excluding windows) is a relatively small share of total embodied carbon (under 3% across every wall variation modelled). Concrete in the foundation and basement walls remains the dominant factor when reducing embodied carbon. The model does not account in detail for mechanical, electrical, and plumbing systems or interior finishes.

The exterior XPS wall produced the largest increase in embodied carbon of any option, but still delivered the second best overall emissions reduction because it cut operational energy demand the most.

Across the board, improving insulation reduced total emissions regardless of the material used or its embodied carbon footprint. Choosing lower embodied carbon insulation on top of that could add roughly 4 additional tonnes of emissions reduction over 30 years. It also reduces emissions today, which has a greater impact on global warming potential.

Biogenic carbon storage potential was most affected by the choice of plant-based insulation materials, such as cellulose; this is where the greatest opportunity lies to maximize storage.

Key Takeaways

- The house model is simplified and relies on regional-average EPD data; treat results as directional guidance rather than exact or precise figures.
- In a high-emitting electricity grid such as Alberta, or where fossil fuels supply heat and hot water, embodied carbon will represent less than 15% of total emissions.
- In that same high-emission scenario, improving insulation (regardless of its embodied footprint) still reduces total emissions.
- Eliminating combustion and adding renewables matters even more in a high-emitting grid.
- Buildings have significant potential to store biogenic carbon, but more clarity is needed on which biogenic materials truly store carbon — for example, whether models crediting the full value of wood mass account for land-use-change emissions from logging, and where cellulose is sourced from. Rapidly grown, easily traceable biomass (such as agricultural waste) is more defensible. Sustainably harvested wood products should only be counted if they have high-quality EPDs. Even conservatively, the model shows a house could store 30–40 tonnes of carbon — typically more than its embodied emissions.
- The largest remaining opportunities to reduce embodied emissions are in the slab, foundation, and basement walls. Mechanical, electrical, and plumbing systems also contribute, though with less room for substitution. Interior finishes and furnishings (which turn over repeatedly over a building's life) also likely matter.