Carbon Impact of Gypsum & Low-Carbon Gypsum

Whitepaper

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Executive Summary

The built environment accounts for 35% of total greenhouse gas (GHG) emissions in North America.[1] While progress is being made to reduce operational carbon through energy efficiency and decarbonization of the electrical grid, embodied carbon reductions are just starting to be prioritized. Low-carbon material sourcing is one obvious solution. In addition to steel and concrete, there is now an opportunity to explore other commonly used materials such as gypsum. Gypsum is ubiquitous in buildings of all classes in exterior and interior walls and ceilings. Thus, using lower-carbon gypsum products can lead to substantial embodied carbon reductions, especially for retrofits, with internal walls showing the greatest impact. These in turn have several benefits including conformance to government regulations and improved scores in voluntary green building certifications.

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Terminology/definitions

Greenhouse Gas (GHG)

Gases in the atmosphere that cause the Greenhouse Effect, thereby raising the temperature of the Earth's surface. Greenhouse gases include carbon dioxide, methane, and many others, and are often measured in carbon dioxide equivalents (CO_2e) or Global Warming Potential (GWP).

Decarbonize

The process of eliminating greenhouse gas emissions from a system such as manufacturing, energy production, transportation, or other.

Embodied Carbon

Emissions produced as a material is made, transported, and installed. The emissions from the raw material extraction, manufacturing, transportation, and construction phases of a product's life cycle.

Operational Carbon

Emissions resulting from the energy used to operate a building or infrastructure.

Lifecycle Assessment (LCA)

Consideration of a product's environmental impacts throughout the supply chain from raw materials sourcing to deconstruction and end-of-life.

Introduction

Every sector must contribute to the global effort of reducing *greenhouse gas* (GHG) emissions to meet international targets of limiting global warming to 1.5℃ above pre-industrial levels, with the aim of preserving the livable global environment.[2] GHGs are a category of gases in the atmosphere that cause warming and other adverse climate effects. The most abundant of these is carbon dioxide. The impact of other GHGs are measured using the 'carbon dioxide equivalent' of a given GHG, referred to as its Global Warming Potential (GWP). This report refers to 'carbon' and 'carbon emissions' interchangeably to represent total the GWP associated with GHGs.

The building and construction sector is among the world's top emitters, contributing nearly 40% of global emissions.[3] These emissions come from the entire life cycle of the built environment, from resource extraction and material production to the energy used to heat, cool, ventilate, and light our buildings. The former refers to *embodied carbon.* Classified within Scope 3 emissions, these are emissions produced as a material is made, transported, and installed (i.e., raw material extraction, manufacturing, transportation, and construction).

Although historic efforts to reduce emissions from the building and construction sector have been focused on *operational carbon* – emissions resulting from the energy used to operate a building –

embodied emissions are an important part of a building's emissions. In fact, in regions with low-carbon energy systems such as in Ontario and Quebec, embodied carbon can make up the majority of a new high-efficiency building's lifetime emissions.[4,5] This is partly due to the fact that operational carbon can be reduced throughout a building's operating life (e.g., switch to energy efficient appliances and cooling systems, etc.), but embodied carbon is realized and emitted in the early design stages of a building when materials are chosen, manufactured, and transported. Once those embodied emissions are generated, the only way they can be undone is through carbon removals. Accordingly, there are now global efforts to *decarbonize* building materials.

The emissions impact of individual building materials and entire buildings can be assessed using a Life Cycle Assessment (LCA). LCAs relate to the different life cycle stages of a building, with products represented in stages A1-A3 (Figure 1).

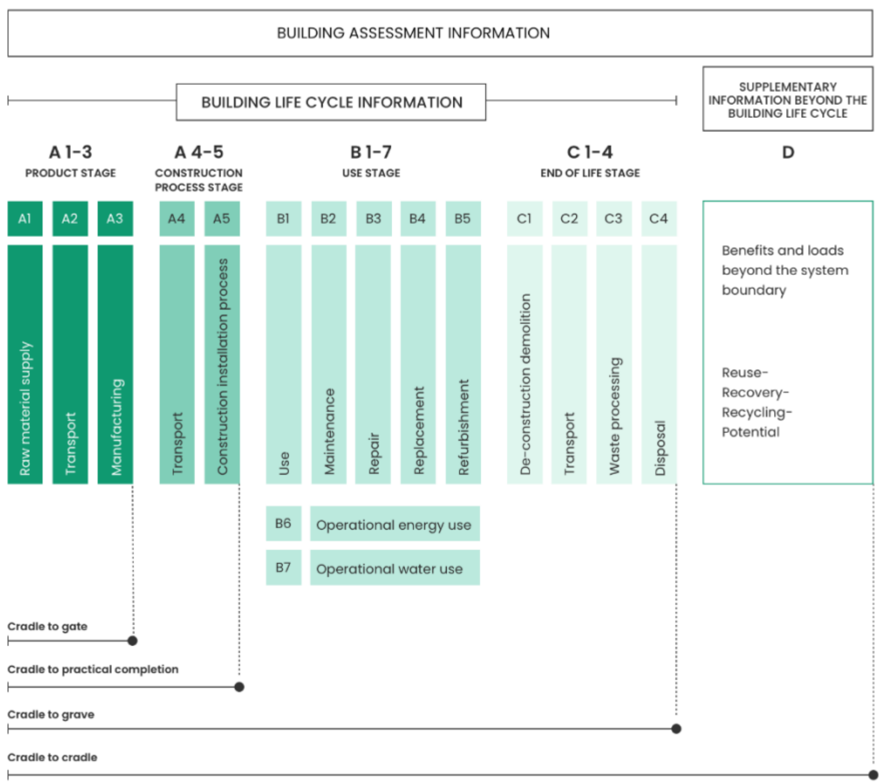


Figure 1: Building life cycle stages as they relate to LCAs.[6]

A report by the UNEP and Yale Center for Ecosystems + Architecture highlights the importance of decarbonizing conventional materials to achieve broader decarbonization goals.[7] This whitepaper addresses the GHG impact of one of the most commonly used building materials: gypsum. Gypsum is a widely used construction material in walls, ceilings, and more. In particular, this paper looks at recent developments in low-carbon gypsum.

Environmental Product Declarations (EPDs)

An important tool in efforts to understand, disclose, and decarbonize building materials is an *Environmental Product Declaration* (EPD). These are third-party-verified reports providing information on a specific material's carbon footprint, aligned with one of a number of international standards such as ISO 21930, ISO 14025, ISO 14040, ISO 14044, and the North American product category rules.[8] For a product to be marketed as low-carbon, it should have an EPD to justify its environmental claims. This ensures transparency and allows consumers to make informed decisions based on the environmental performance of the materials they use. As most major manufacturers now establish EPDs for their products, EPDs are a useful tool to understand the environmental impact of products.

It is important to note that EPDs can be created at various levels of specificity. An EPD could use global averages as proxies for missing data, or use data specific to a country, company, or even an individual manufacturing facility. Since EPDs are intended to indicate carbon impact, the more specific and therefore accurate an EPD can be, the better. Thus, an ideal EPD from an accuracy perspective is a plant-specific (also called facility-specific) EPD. EPDs are increasingly common and provide useful data on the embodied emissions of a product or material. The increase in EPDs is in part a response to a number of regulatory requirements and/or voluntary measures requiring embodied carbon in buildings and materials to be disclosed and reduced.

Policies

Policy is an important tool to encourage the market towards low-carbon decisions and to shift industry toward national and international climate goals. In Canada, there are a number of key building decarbonization policies at the federal, provincial, and municipal levels.[9] A small sample of examples are provided below.

Federal

- The Canada Green Buildings Strategy supports decarbonizing the building sector by phasing out oil heating systems.
- The National Building Code and National Energy Code ensure emissions reductions through minimum energy efficiency requirements in buildings and are expected to include operational carbon requirements in 2025 and embodied carbon requirements in 2030.
- The Government of Canada's Standard on Embodied Carbon in Construction requires lower carbon materials to be used on federal projects but is currently limited to ready-mix concrete. Additional materials are expected to be added over time.

Provincial

- Under Quebec's Environment Quality Act, regulations prohibit oil-fired heating in residential buildings.

Municipal

- Vancouver has mandated that all new permanent air-conditioning systems in existing homes must be low-carbon electricity-powered.

- Vancouver introduced building performance standards requiring energy and carbon reporting and GHG limits.
- The Toronto Green Standard requires sustainable design and performance from new buildings to reduce energy use and emissions, and contribute to other climate-positive outcomes.[10] Embodied carbon requirements currently exist for City-owned new construction. They are expected to apply more broadly in the coming years.

Beyond government bodies, independent organizations have developed various standards and programs to guide those in the building sector toward decarbonization goals.

Leadership in Energy & Environmental Design (LEED)

- LEED is an international, voluntary, third-party verification system that certifies building projects as achieving high performance across six categories including energy efficiency and materials selection.[11] In doing so, LEED guides and incentivizes climate-positive building, while highlighting the importance of low-carbon materials and building operations.

Zero Carbon Building (ZCB) Standards

- The Canada Green Building Council (CAGBC) developed the Zero Carbon Building standards, another voluntary program to certify energy-efficient, zero-carbon buildings. The program offers certification under two streams: the Performance Standard and the Design Standard. The former focuses on zero-carbon operation of a building, while the Design Standard recognizes zero-carbon efforts in the design phase which can optimize building material choice to tackle embodied emissions.[12]

GHG Protocol Standards

- The GHG Protocol sets out corporate GHG reporting standards in company value chains (i.e., Scope 3/embodied carbon) and operations.[13] Within the GHG Protocol standards is the Corporate Value Chain (Scope 3) Standard. This specifically guides companies to account for and report emissions throughout their supply chains, while identifying opportunities for carbon reductions.[14]

Science-Based Targets Initiative (SBTi)

- The SBTi is a framework that guides corporate actors to establish the science-based climate targets necessary to align their operations with the Paris Agreement's 1.5℃ mandate. In August 2024, the SBTi released the Building Sector Science-Based Target-Setting Criteria – a whole-building decarbonization framework specifically for companies in the building sector. This framework includes embodied and operational reduction targets.[15]

Some firms, such as Gensler, are developing their own standards, signaling the seriousness of considering structural materials and building interiors.

Gypsum Manufacturing

Gypsum Sourcing

Gypsum is a naturally occurring sulfate mineral with many uses, especially in the construction sector. Gypsum is used for plasterboards and to make cement, alongside other accessory uses due to its water- and fire-resistant qualities and soundproofing. Primary gypsum can be sourced in two ways: mined gypsum and flue gas desulphurized (FGD) gypsum.

> **Mined gypsum** is the most common method of obtaining raw gypsum in North America. Gypsum is a soft mineral, making it easy to extract from quarries with drilling and blasting or surface mining methods.[16] It is mined in over 90 countries.[17]
>
> **FGD gypsum** is sourced as a byproduct of coal power generation.[18] Combustion of coal releases sulphur dioxide (i.e., flue gas), which is reacted with other elements to produce calcium sulfite sludge (i.e., FGD gypsum). The remaining flue gas from this process is released into the air and the FGD gypsum is further refined to be ready for industrial use.

In addition to primary sources, **recycled gypsum** is gaining in prevalence. While it is more common in Europe, North American manufacturers are starting to source more recycled gypsum as well. This source is generally preferred since common carbon accounting methods consider recycled materials to have no/low embodied carbon.

Among primary sources, mined gypsum is the most common in North America. With coal power plants being phased out in North America due to their heavy GHG emissions, FDG gypsum continues to become less prevalent in the market. Between the United States and Canada, the United States produces the majority of what FDG gypsum is in circulation, as they have much larger gypsum markets overall, and rely on coal to a much greater extent than Canada. Globally, the United States is one of the largest gypsum-producing countries, alongside Iran, China, and Spain.[19] Canada is a significant producer of mined gypsum, with mining operations in Nova Scotia, Ontario, Manitoba, and British Columbia, and gypsum product manufacturers in many provinces.[20]

Gypsum Board Manufacturing in North America

One of gypsum's primary uses is gypsum boards – a material used in walls and ceilings. Traditionally, manufacturing gypsum boards involves a multi-step process of dehydrating, hydrating, and once again rehydrating raw gypsum. In doing so, raw gypsum is calcined, purified, and transformed into a slurry that can be shaped into panels or boards and laid between layers of paper. Once shaped, the material is reverted to its solid state, now bonded to the paper layers and dehydrated of any excess moisture.[21] This process, in addition to the initial mining of gypsum or production of FGD gypsum, requires energy typically derived from fossil fuels. Although gypsum is not among the most carbon-intensive materials, it is very commonly used as it has many building applications. Therefore, its carbon impact can add up, and addressing the embodied carbon emissions in gypsum boards is important.

In North America, the low-carbon gypsum market is nonexistent, with one primary exception. The first **low-carbon gypsum manufacturing facility** run by international gypsum producer Saint-Gobain, through its subsidiary CertainTeed Canada, will begin operations in 2025 in Montreal, Quebec. To achieve near-zero Scope 1 and 2 emissions, the facility is reducing its energy use by 30% and is powered entirely by the Quebec grid, which is mainly hydroelectricity.[22] This will replace traditional natural gas power systems which emit GHGs including carbon dioxide, nitrogen oxides, carbon monoxides, volatile organic compounds, and more.[23]

Overall, the Montreal facility will:

- replace natural gas burners with efficient, hydroelectric-powered heating elements,
- implement heat recovery,
- improve compressed air design,
- install energy meters and energy management systems,
- upgrade equipment insulation,
- add process sensors to monitor and improve production quality, and
- increase recycled content by using pre- and post-consumer waste.

The next steps to reduce Scope 3 emissions, in addition to Scope 1 and 2, would involve addressing low-carbon alternatives in the supply chain of raw gypsum and in manufacturing methodologies.

Market Scan & Emissions Comparison

While some of the world's largest gypsum manufacturers are in Europe and Asia, North America is becoming an increasingly relevant player with numerous large companies operating in the United States and Canada.

Saint-Gobain is one of the world's large gypsum manufacturers. The France-based company uses both mined gypsum and recycled content. It manufactures globally, and increasingly in North America. Saint-Gobain offers gypsum products under five brands: Gyproc, Placo, Rigips, British Gypsum, and CertainTeed. Their gypsum products include plasterboards, plasters, and ceilings with individualized uses, including for harsh external weather conditions, to improve indoor air quality, and other standard gypsum applications. Saint-Gobain has focused on sustainable gypsum production for many years and is now bringing these practices to North America with a new low-carbon gypsum plant in Montreal.

Other large gypsum producers include Knauf/USG, National Gypsum, and Georgia-Pacific Building Products. USG merged under Knauf in 2019 and Knauf/USG represents a significant portion of the gypsum industry. USG is the American parent company of their Canadian gypsum products, which are under the Canadian Gypsum Company Inc. (CGC) brand. USG CGC focuses on sustainability through resource efficiency and reducing waste. Their Ecoblueprint strategy is publicly available and outlines their path to achieving emissions reductions, waste diversion, and conducting LCAs on all product lines. In addition, USG CGC publishes EPDs for a number of their gypsum products.

National Gypsum has five brands producing gypsum products: Gold Bond, PermaBASE, ProForm, DEXcell, and Purple Drywall Board. These brands produce drywall, plaster, industrial products, cement boards, ready-mix and other finishing products, and roofing products for various factory-built housing and industrial uses. National Gypsum's Gold Bond Building Products brand owns and operates some of the largest gypsum quarries in the United States and Canada, and therefore controls its own gypsum supply.

While National Gypsum does not publish much on its sustainability efforts, Georgia-Pacific Building Products conducts cradle-to-grave LCAs for all of its products and produces EPDs. Georgia-Pacific Building Products offers standard and more specialized gypsum board, plaster, ceiling board, and more. Their products of varying weights and durability demonstrate fire resistance, mould resistance, and other desirable features of gypsum products.

Figure 2 compares the most significant gypsum board manufacturers in eastern Canada and New England. It compares Type III EPDs for four products and an early estimate of Saint-Gobain's A1-A3 emissions for their new Montreal facility. Saint-Gobain's low-carbon gypsum product demonstrates the potential for significant embodied carbon reductions in the industry.

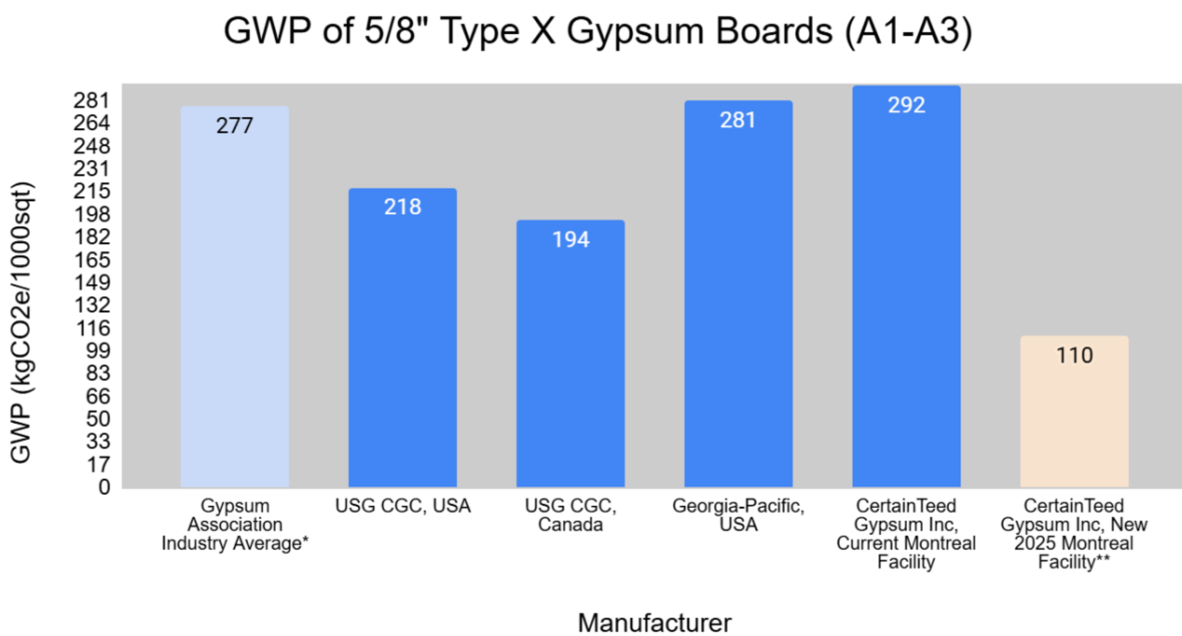


Figure 2: Comparison of the GWP of ⅝" Type X gypsum boards across some North American companies

*The gypsum association industry average includes companies shown above and others

**This value is an early estimate based on Saint-Gobain's Montreal Gypsum Panels LCA Action Plan. This number may change once real data becomes available [24]

These large companies have the opportunity to be leaders in sustainable gypsum production, as these practices are still emerging in the industry. Looking at Saint-Gobain's processes for their Montreal plant, they found the most opportunity for emissions reductions in the product life stages A2 and A3 – see below.[24] They aim to start production in 2025.

1. Transportation of raw materials (A2)
    - Increase recycled content by up to 30% to reduce the need for transportation of new materials, which can reduce the GWP of production in this life cycle phase by up to 30%.

2. Manufacturing (A3)
    - Replace gas-fuelled heating systems with highly efficient electrical ones plugged into Quebec's renewable-heavy grid, which can reduce the GWP of production in this life cycle phase by nearly 100%.

Expanding the consideration to include transport-to-site emissions (A4) can also yield benefits. Selecting gypsum manufacturers located close to the construction site and using rail instead of trucking can significantly reduce the embodied carbon of construction projects. Considering construction sites in a few North American cities, it is apparent that transport distances can vary significantly (see Figure 4).

Figure 3 shows that the transport-to-site impacts the emissions profile of gypsum board and can lead to different manufacturers having the lowest overall emissions. Many of the modeled transportation routes include both rail and trucking, each of which has a very different emissions profile. See the Appendix for a site-by-site emissions breakdown.

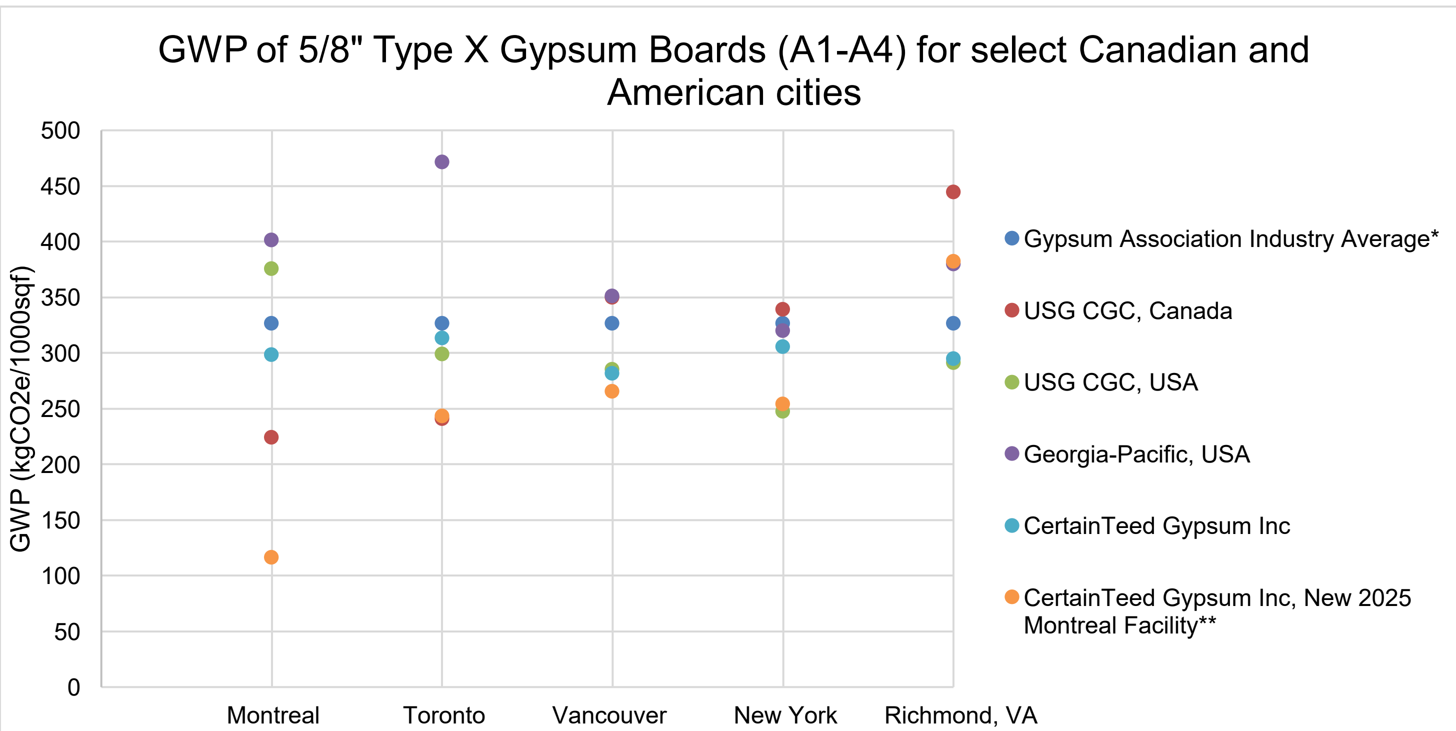


Figure 3: Comparison of the GWP of ⅝" Type X gypsum boards for select Canadian and American cities (A1-A4)

*The gypsum association industry average includes companies shown above and others

**This value is an early estimate based on Saint-Gobain's Montreal Gypsum Panels LCA Action Plan. This number may change once real data becomes available [24]

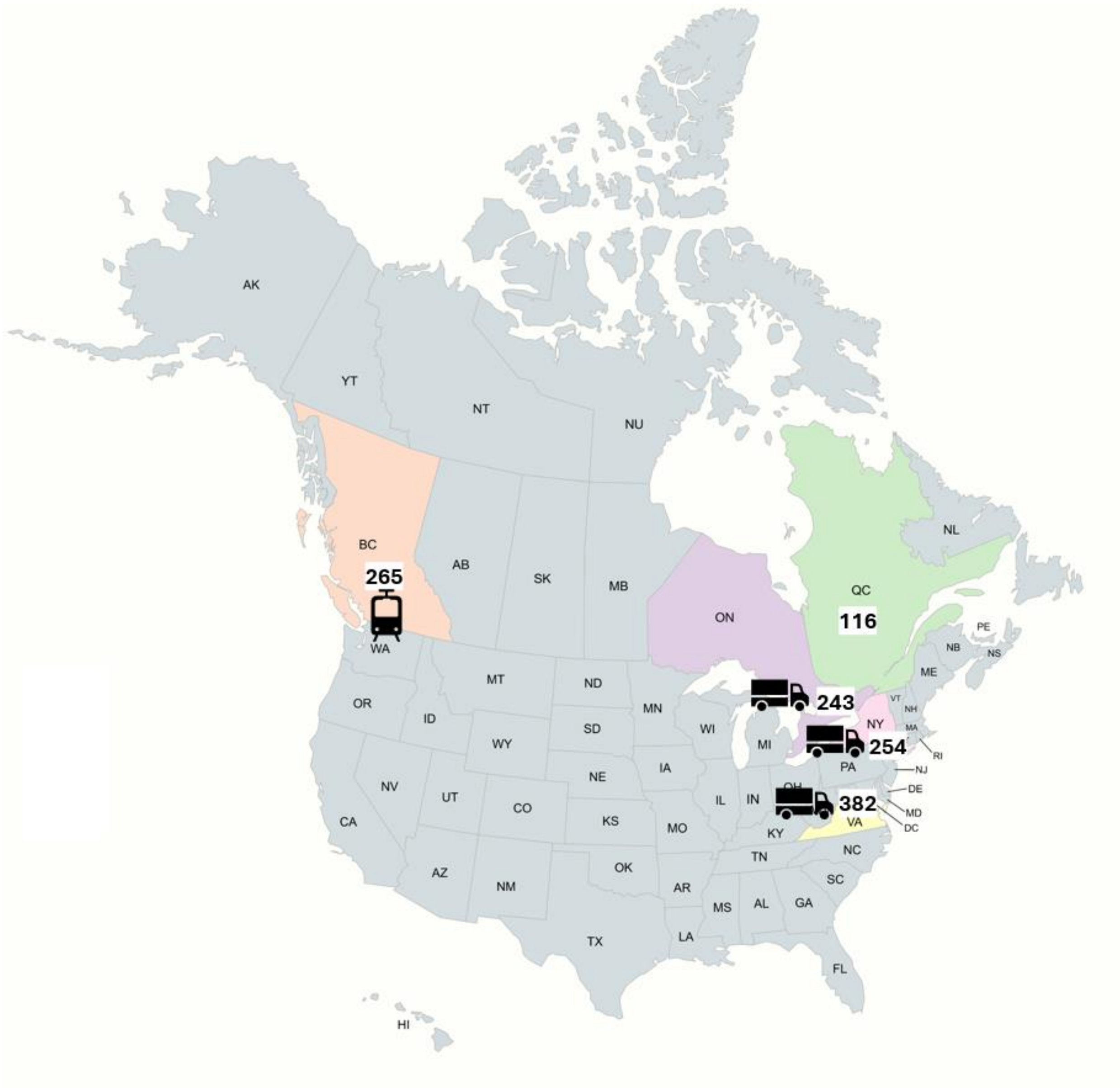


Figure 4: Map of North America with highlighted target cities and corresponding GWP (A1-A4) of Montreal Type X board

Gypsum Contribution to Wall Assemblies

The contribution of gypsum products to the embodied carbon of buildings is infrequently discussed in a North American context. To date, concrete and steel have dominated the discussion on low-embodied carbon materials. While these are large drivers of embodied carbon, achieving net zero goals will require reductions in carbon from all materials. The following section details the impact of gypsum products on the embodied carbon of typical wall systems in the Toronto area.

Common Gypsum Products in Walls

Gypsum is primarily used in walls because of its fire-resistant properties, mould-resistance, and relative lightness compared to other fireproofing solutions.[25] The commonly used products for internal walls are Standard, Type X, and Type C gypsum boards.

- Standard paper-faced gypsum board typically includes gypsum with no other fireproofing additives.
- Type X, in order to attain a fire-resistance rating as defined by ASTM C1396, has glass fibres included in the gypsum mixture.[26] These fibres reduce cracking when high temperatures dehydrate the gypsum.
- Type C gypsum panels are not ASTM C1396 regulated, but are tested by UL. They have a higher fire rating, for the same thickness, from the inclusion of more glass fibres by weight along with vermiculite.[27]

External wall segments may also include gypsum products. Exterior gypsum sheathing includes a Type X gypsum panel faced with fibreglass sheets. These panels offer excellent fire, water, and mould resistance, which can be valuable for wall assemblies that require additional weatherproofing during and beyond the construction phase.

Review of Common Wall Assemblies in the Toronto Area

Wall assemblies in the Toronto area use a variety of materials. They are typically clad in brick, stone, or concrete, with more recent construction also using metal sheeting. In 2024, RDH Building Science and the Toronto Metropolitan University conducted a comprehensive review of the most commonly used wall assemblies.[28] They considered new construction, from the outer cladding to the interior paint finish. They also considered wall assemblies added over or behind existing masonry, which this whitepaper uses as a proxy for cladding retrofits. Building retrofits are gaining attention as a solution to high operational carbon emissions from older buildings while minimizing embodied carbon. The embodied carbon considerations for retrofits are quite different from new builds because of the relative lack of new high-emitting materials. In this case, other materials, such as gypsum, have a higher emissions share.

This section provides an overview of the findings from the RDH study as they relate to low-carbon gypsum, considering new construction (internal and external walls) and retrofits. Internal walls, as specified in Certainteed's Gypsum and Insulation Systems Manual, are also included. For more details on the methodologies used and wall assemblies studied, see the appendix.

The study focuses on embodied carbon to provide guidance for developers making early-stage design comparisons. In order to make representative embodied carbon calculations, a 3-metre by 3-metre wall section is considered so that relevant repeating internal structures are included. A segment of this size includes multiple studs. Life cycle stages A1-A5 are included. The bulk of emissions for all wall assemblies are found to be from raw material processing, manufacturing, and transportation (A1-A3), with transportation to the construction site (A4) and construction (A5) being relatively smaller sources of emissions.

Each wall assembly can be broken down into the following components:

- Cladding - can include gypsum
- Insulation
- Back-up structure
- Interior finish - always includes gypsum

Figure 5 provides information for a typical brick wall assembly. It shows all the material layers, their total GWP, and the breakdown by LCA phase. Refer to the appendix to see all the typical wall assemblies.

The majority of a wall assembly's GWP is found to be from the cladding, insulation, and back-up structure.

Metrics	Results
Description	**Exterior Insulated CMU with Brick Veneer**
Effective R-value	RSI-4.6 m²K/W | R-26 ft²·°F·h/BTU
Embodied Carbon per m² of Enclosure (A1-A3)	136.3 $kgCO_2/m^2$
Biogenic Carbon per m² of Enclosure	0 $kgCO_2/m^2$

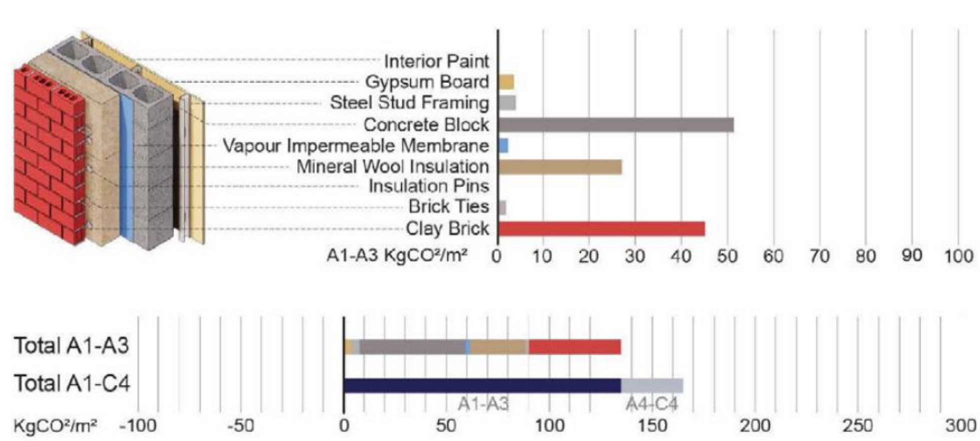


Figure 5: Material and GWP breakdown of a typical wall assembly - Exterior Insulated CMU with Brick Veneer [28]

Carbon Impact of Non-gypsum Wall Components

In most typical wall assemblies considered, the amount of gypsum used is generally very consistent. Variations in embodied carbon, therefore, are due to other wall components. In order to better frame the impact of gypsum on wall assemblies, a brief description of all wall components is outlined.

Influence of Cladding Type

Cladding type strongly influences the total GWP of each wall assembly. The materials considered range from masonry elements to metal sheeting to exterior insulation and finish systems (EIFS). Overall, thinner elements have lower associated emissions. Different manufacturing processes for cladding also considerably impact the GWP of the cladding and wall assembly.

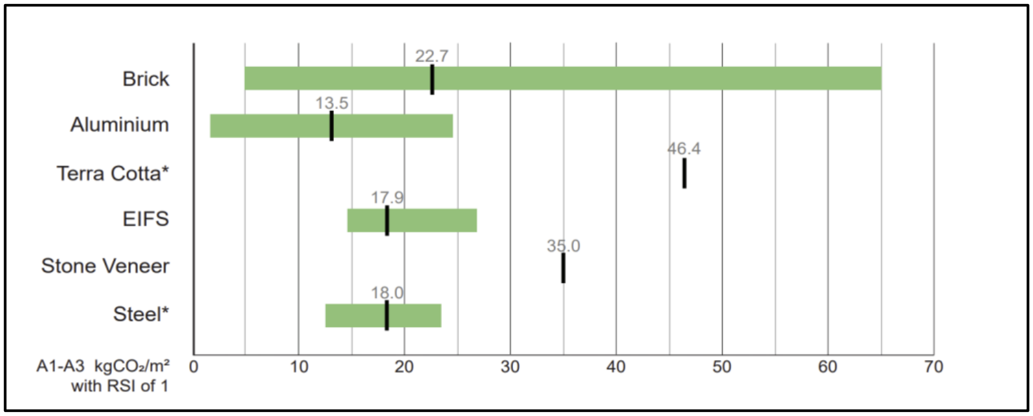


Figure 6: Comparison of the embodied emissions of cladding products for stages A1-A3 [29]

Influence of Insulation Type

Mineral wool is by far the most common type of insulation. XPS, EPS, and polyiso are also used. The embodied carbon of each varies significantly based on the technologies used to manufacture and install each product. Special care should be taken when installing XPS to choose a low-GWP blowing agent.

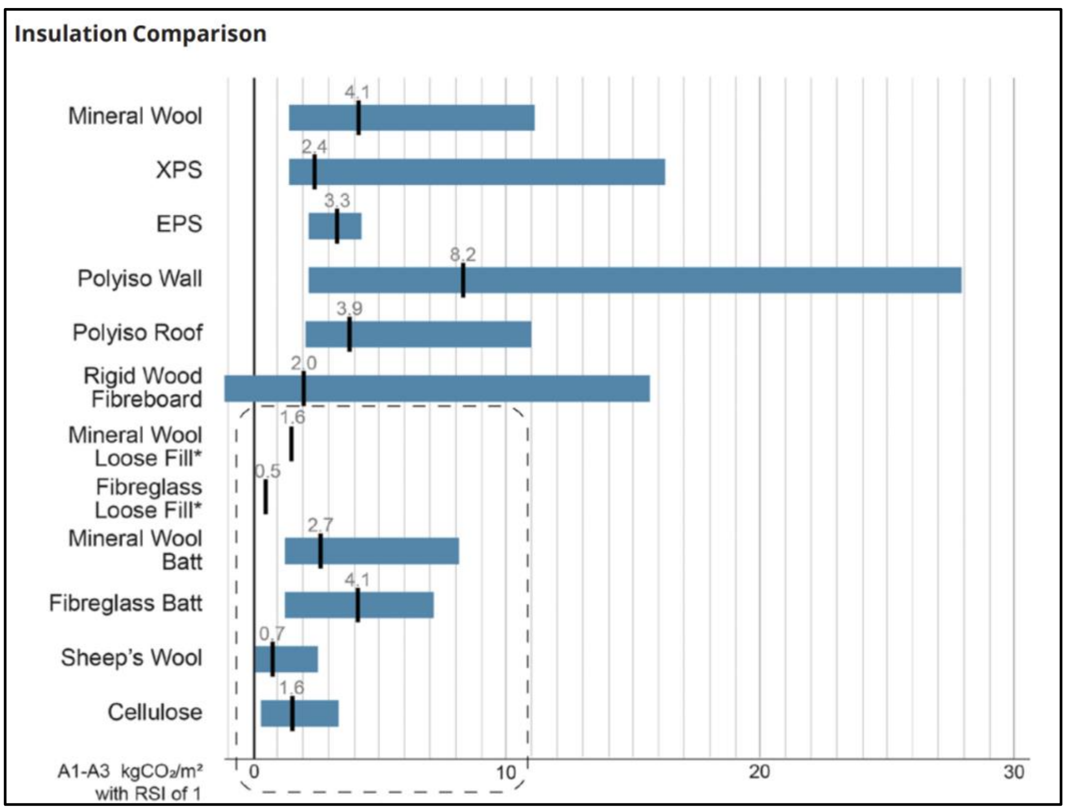


Figure 7: Comparison of the embodied emissions of insulation materials for stages A1-A3 [30]

Influence of Back-up Structure

The back-up structures commonly used in the Toronto area are steel and wood studs, as well as concrete. Steel and concrete are generally used for taller buildings whereas wood is used for detached homes and townhouses. Wood has a considerably lower GWP than the other options and also stores biogenic carbon.

Influence of Gypsum for External Wall Assemblies - New Construction

All of the studied wall assemblies in the Toronto area have gypsum boards in the inner portion of the wall. The quantities used are identical, so the relative impact of gypsum on the GWP of each wall segment is determined by the other wall components. The GWP of gypsum board for the 3m x 3m wall segments being studied is 26 kg CO_2e. Certain wall assemblies require additional fireproofing elements, such as gypsum or concrete sheathing. Gypsum has substantially lower embodied carbon than concrete, contributing 42 kg CO_2e for the studied wall segment. The emissions associated with gypsum products range from 1.7% to 5.8% for all the new construction wall assemblies considered.

This is a nontrivial percentage of a wall's GWP, and choosing a lower-carbon gypsum is a simple way to further total building decarbonization in a way that does not affect construction timelines. Furthermore, the relative embodied carbon contribution of gypsum increases significantly when considering building retrofits that don't involve new cladding systems.

Influence of Gypsum for External Wall Assemblies - Building Retrofits

An increasing number of jurisdictions at all levels of government, including the City of Toronto, are emphasizing retrofits as dual strategies promoting operational and embodied carbon reductions. When considering a building retrofit that preserves the exterior cladding, traditional high-impact materials like concrete and steel are largely absent. Naturally, this leads to significant embodied carbon reductions when compared to traditional building demolition and new construction.

The embodied carbon considerations of retrofits are quite different from new builds. Without the highest-emitting materials, others such as insulation, gypsum board, and internal finishes dominate the embodied carbon picture. For those interested in reducing the carbon impact of their retrofits, it is therefore essential to consider material selections that may otherwise be overlooked. Since low-carbon gypsum board has the same functional properties and supply chain as traditional gypsum products, this is an easy first start where supply exists.

Metrics	Results
Description	**Existing Masonry with Interior Spray Foam Insulation**
Effective R-value	RSI-4.7 m^2K/W | R-26.8 $ft^2 \cdot °F \cdot h/BTU$
Embodied Carbon per m^2 of Enclosure (A1-A3)	9.8 $kgCO_2/m^2$
Biogenic Carbon per m^2 of Enclosure	0 $kgCO_2/m^2$

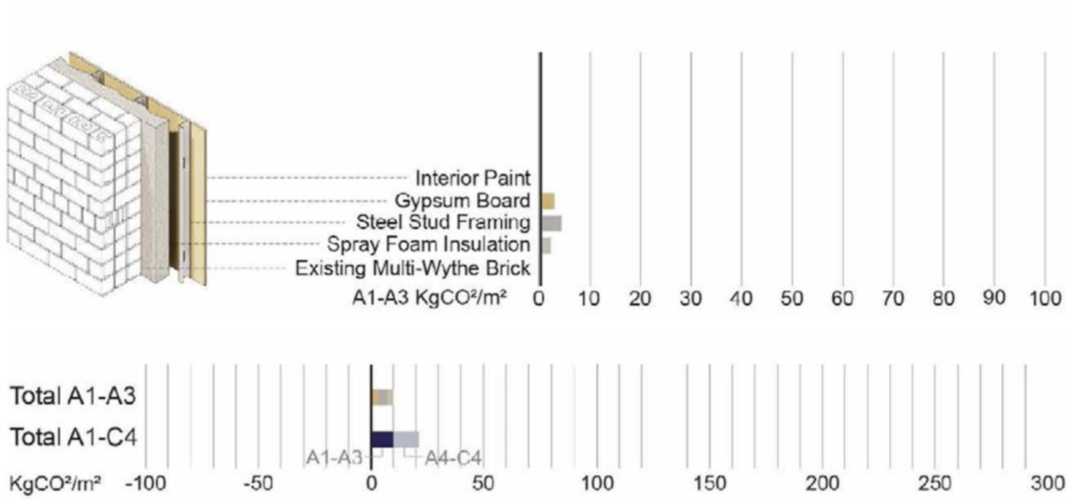


Figure 8: Material and GWP breakdown of a wall retrofit - existing masonry with interior spray foam insulation [28]

When a complete wall assembly is added onto an existing masonry frame, as shown in Figure 8 above, gypsum board can account for nearly 30% of the total GWP.[31] This figure excludes the embodied carbon of the masonry itself. Many building retrofits will keep the outer cladding, for historical preservation or cost savings. In such construction, it is clear that gypsum board has a larger impact on the GWP, making material sourcing here important for the embodied carbon of the project.

Influence of Gypsum for Internal Wall Assemblies

Internal wall assemblies are gypsum-heavy building components. They are fairly standard, typically including steel or wood studs and Type X gypsum board on both sides. Depending on the acoustic requirements, insulation can be added for sound damping. Figure 9 below shows a typical wall assembly using Type X gypsum board.

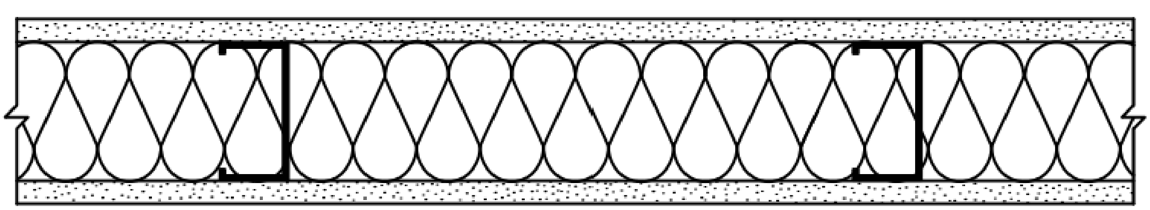


Figure 9: 1-hour fire-rated internal wall assembly with steel studs and glass fiber insulation (ULC U411) [32]

The relative contribution of gypsum to the GWP of internal walls is much higher than for external wall assemblies, ranging from 66% to 80% for typical fire-rated wall assemblies (ULC U411 and cUL U309, respectively. See wall assembly details in the appendix).[32,33] Therefore, the potential impact of using lower-carbon gypsum is significant. When considering building retrofits, replacing internal walls will also account for a significant portion of the project's embodied carbon emissions.

Conclusion

Gypsum-based materials are found throughout the built environment. Their fire and mould resistance, along with good sound-damping properties, make them extremely useful for interior finishes. Gypsum board, in the Toronto area, is ubiquitous in wall assemblies. Reducing the global warming impact of gypsum, therefore, has the potential to scale emissions reductions as the construction industry decarbonizes. A review of common wall assemblies demonstrated that early design choices can have a large impact on the embodied carbon of the overall product. Significant carbon savings come from changes in cladding material, insulation material, and back-up structure. The contribution of gypsum to external wall assemblies, while lower than other wall components, is nonetheless significant, ranging between 1.7% - 5.8%.

Gypsum is a contributor to the embodied carbon of new construction. However, greater focus is now being placed on retrofits of existing buildings where the impact of gypsum is higher. Retrofits typically have lower embodied emissions than new builds since the high-embodied carbon structural systems are often retained, and in some cases, the envelope is also retained. For the construction industry to decarbonize, a much stronger emphasis must be placed on retrofits. Typically, these projects leave a building's core and shell untouched. When considering the interior elements of a building, materials such as gypsum become much larger contributors to the overall embodied emissions of the project. In this situation, using gypsum board with lower embodied carbon will lead to significant carbon reductions.

Additionally, early adoption of low-carbon gypsum and building materials helps stabilize a company's supply chain. Developing mature relationships with low-carbon suppliers will be advantageous as demand for specific low-carbon materials increases. This competitive edge will be crucial as these materials become mainstream. Early adoption and familiarity with low-carbon materials will position companies as industry leaders.

Green Gypsum & Other Low Carbon Initiatives

In addition to gypsum's GWP contribution to facades and especially interior walls, low-carbon gypsum complements and can boost other low-carbon initiatives. Decarbonization is multifaceted, and low-carbon gypsum presents an important opportunity to contribute a piece to the puzzle. Low-carbon gypsum contributes to a number of Environmental Quality credits within the **LEED rating system** including but not limited to:

- Indoor Environmental Quality: Acoustic Performance
- Indoor Environmental Quality: Low-emitting Materials
- Indoor Environmental Quality: Construction Indoor Air Quality Management
- Materials and Resources: Sourcing of Raw Materials

- Materials and Resources: Building Product Disclosure and Optimization - Material Ingredients
- Materials and Resources: Environmental Product Declarations

With possible LEED credits in numerous categories, low-carbon gypsum can contribute to a higher overall LEED score and certification.

In addition to LEED certification, low-carbon gypsum can play an important role in regional decarbonization efforts and standards. For instance, the **Toronto Green Standard** Version 4 requires lower-carbon construction materials to limit embodied carbon from new city-owned developments, and optionally from private building projects. Utilizing low-carbon gypsum can help achieve emissions reductions. The Toronto Green Standard is a leading jurisdictional standard in North America and it forecasts the direction of more widespread regulatory guidance to come. In fact, other jurisdictions across North America are already rolling out 'Buy Clean' policies, some of which are likely to apply to interiors and gypsum.[34] This demonstrates the importance of finding lower-carbon alternatives in the design, procurement, and construction stages of a building project. Low-carbon gypsum presents an opportunity for this.

Increasingly, public and private organizations are also setting **internal GHG reduction targets**. These are often aligned with voluntary performance standards and guidance such as the GHG Protocol and SBTi. Alongside other industry-accepted standards, the GHG Protocol and SBTi focus on addressing the whole-building life cycle and embodied carbon reductions. Low-carbon gypsum's contribution to GHG reductions in the life cycle stages A2-A3 demonstrates this material's importance in achieving internal and external mandated carbon reduction initiatives.

As stated previously, decarbonization is multifaceted and decarbonizing the building sector will require efforts on all fronts. It will be necessary to explore lower-carbon alternatives to all building materials, alongside procurement, construction, and building operation considerations. Deploying lower-carbon versions of very common materials such as gypsum will be crucial to achieving sector-wide decarbonization. Low-carbon gypsum is an important example of progress that can be achieved from common building materials today.

Policy Considerations

Although the Toronto Green Standard remains a leading regulatory instrument in North America, more thorough and widespread policy is needed to guide industry toward decarbonizing building materials.

The aforementioned policies do not yet explicitly incentivize low-carbon materials, instead focusing for now almost exclusively on concrete and steel. Stronger policies to decarbonize building materials such as gypsum are needed to push industry towards making low-carbon solutions the standard. Such policies are also needed to give clearer and more standardized direction to those who are ready to start decarbonizing today but may not know where to begin. Thorough policy can also better connect building material decarbonization efforts between public and private sectors, and across building sector stakeholders to cover decarbonization from 'cradle to grave'.

Reducing Scope 3 emissions is a necessary component of decarbonizing the building sector and today's world more broadly. Building materials are important players in life cycle stages A1-A5 of buildings, and are therefore necessary in achieving Scope 3 milestones. Gypsum has an important role in this, as gypsum products are some of the most commonly used in buildings.

Appendix

Breakdown of A1-A4 embodied carbon emissions for 5/8" Type X gypsum board from several manufacturers with multiple destination cities

The following figures provide a detailed breakdown of A1-A4 emissions by destination city. Transportation distances were determined by taking the closest manufacturing plant to the destination. It was assumed that the transportation distance in all cases for the industry average gypsum was 200 km, which is the default in OneClick LCA. This follows guidance from the NRC LCA practitioners guide.

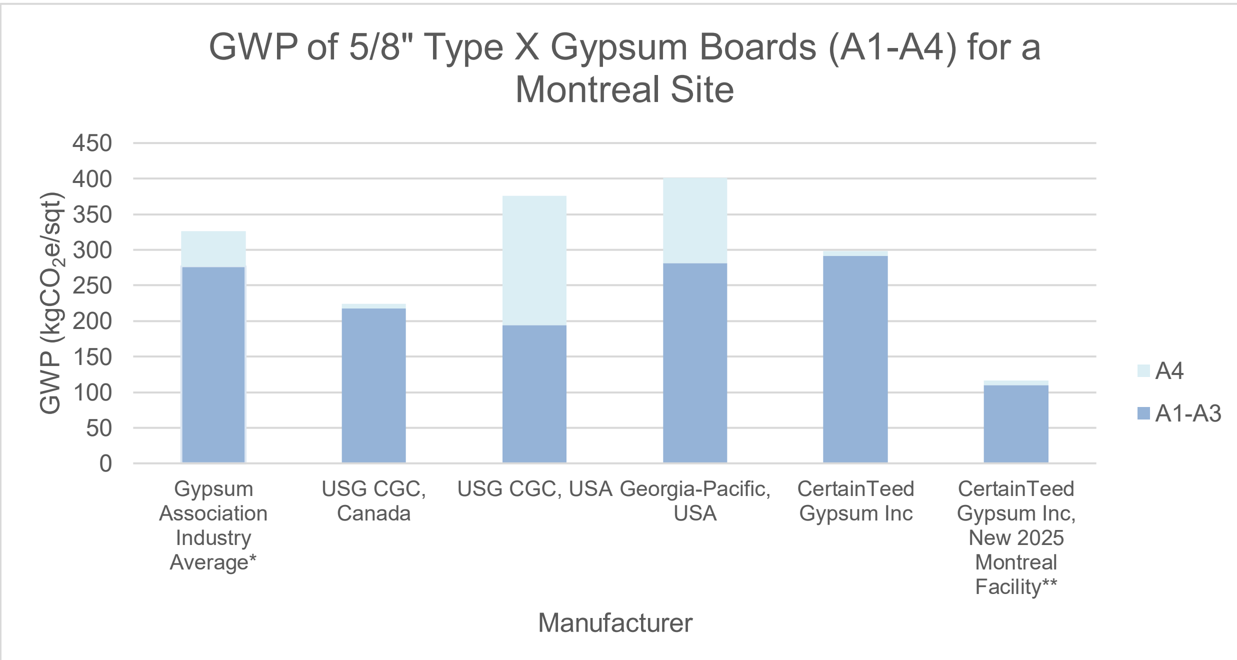


Figure 10: Comparison of the GWP of ⅝" Type X gypsum boards for a Montreal site (A1-A4)

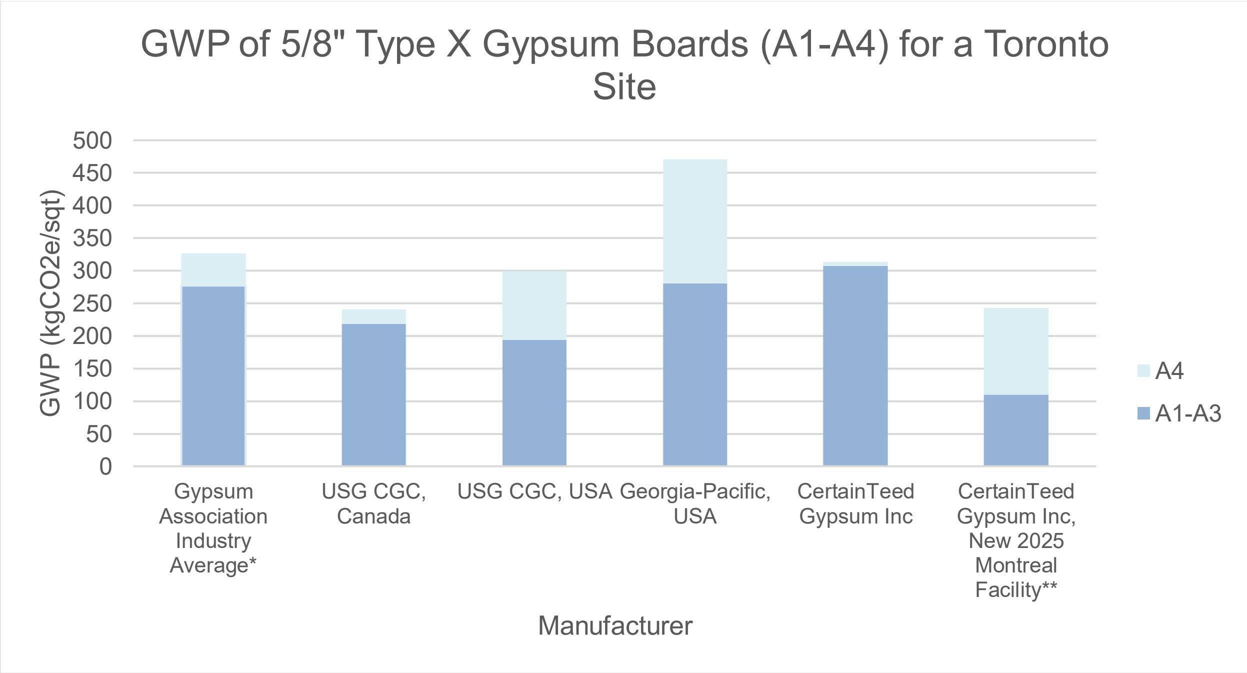


Figure 11: Comparison of the GWP of ⅝" Type X gypsum boards for a Toronto site (A1-A4)

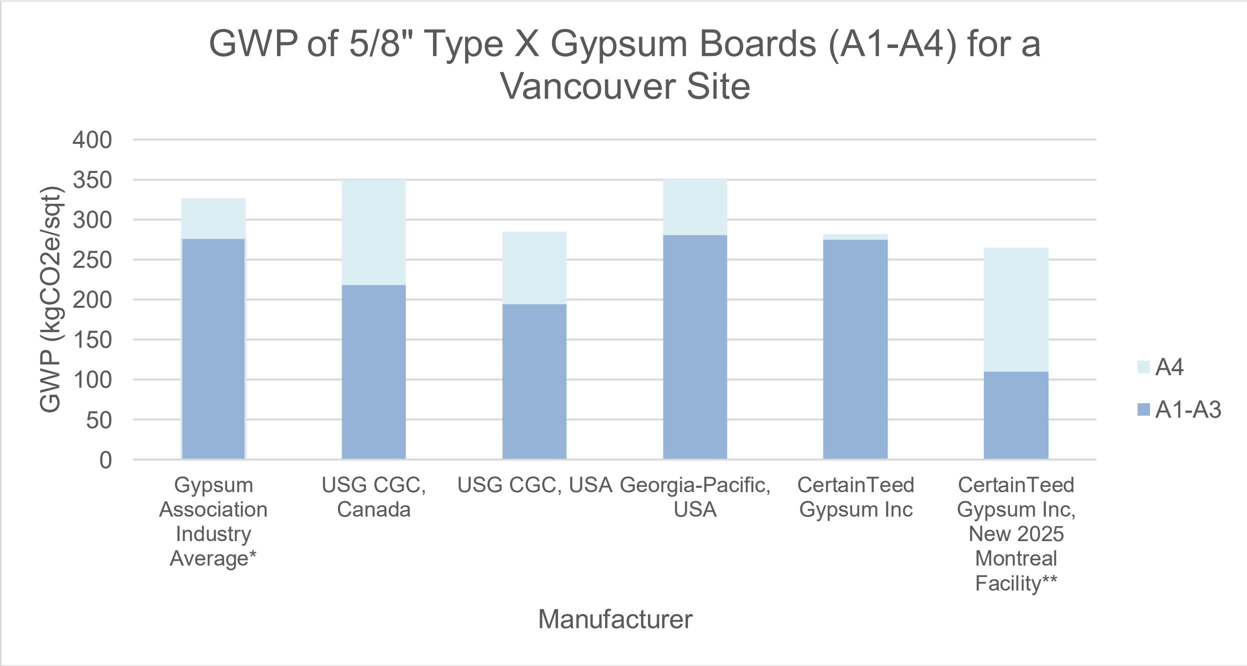


Figure 12: Comparison of the GWP of ⅝" Type X gypsum boards for a Vancouver site (A1-A4)

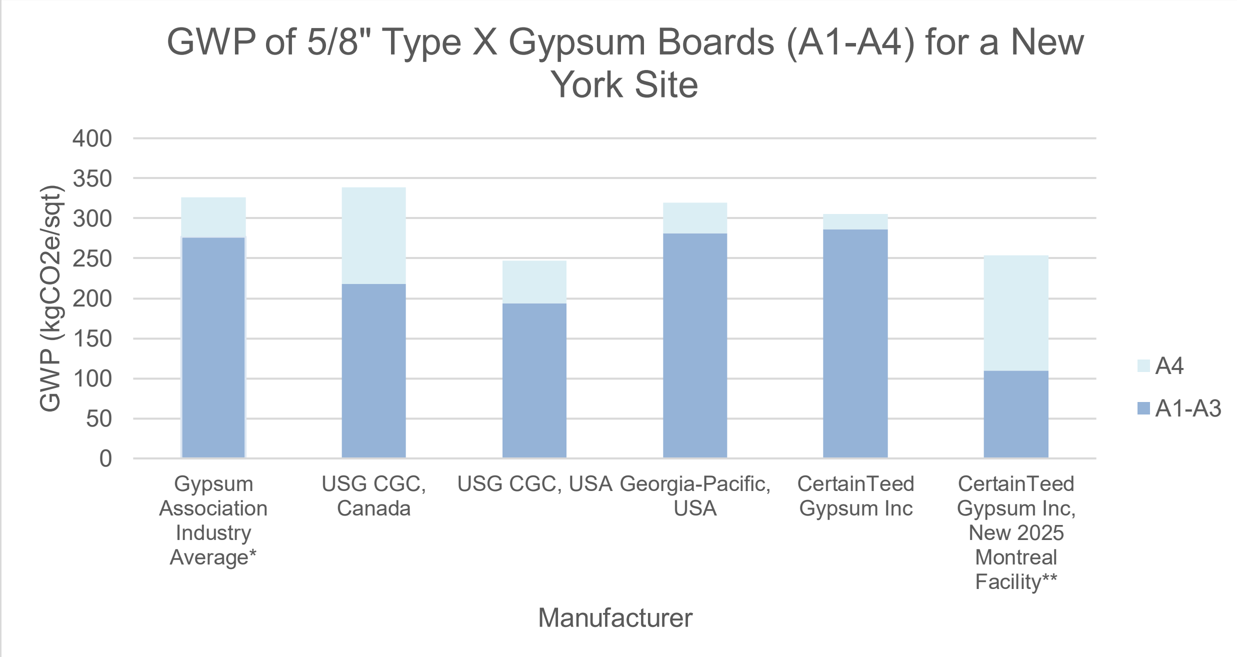


Figure 13: Comparison of the GWP of ⅝" Type X gypsum boards for a New York site (A1-A4)

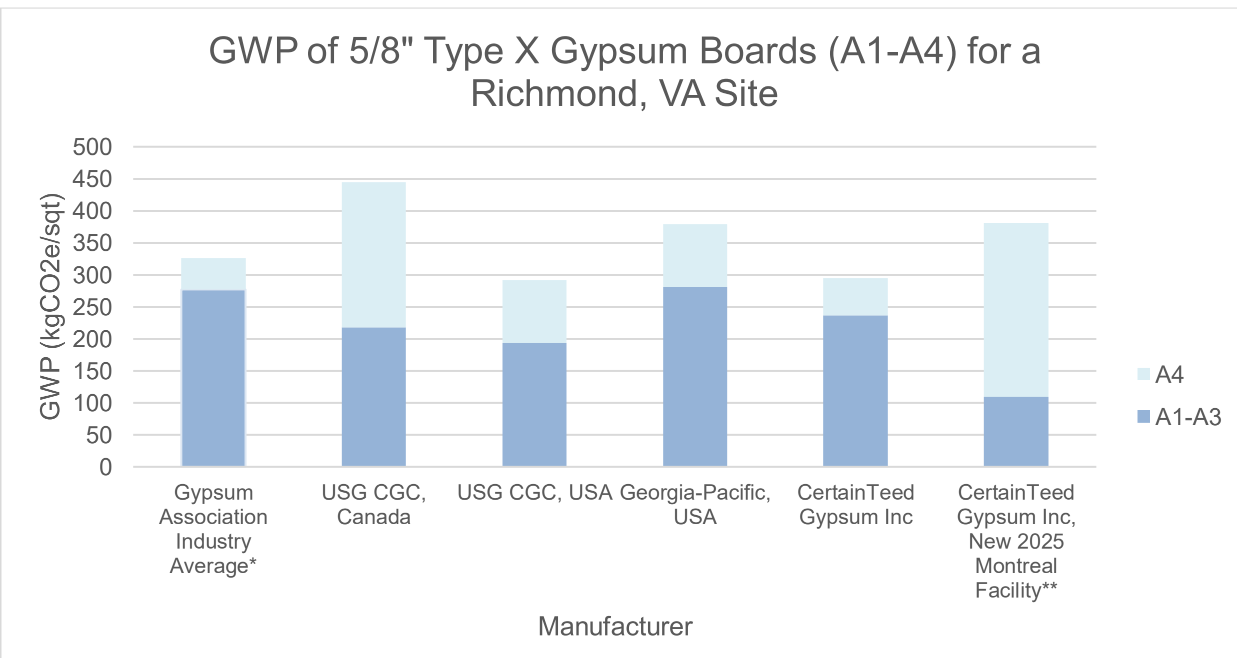


Figure 14: Comparison of the GWP of ⅝" Type X gypsum boards for a Richmond, VA site (A1-A4)

Typical External Wall Assembly from the RDH's 2024 Comparative Study: New Design Resources for Embodied Carbon Targets

Metrics	Results
Description	**Insulated Metal Panel with Mineral Wool Insulation**
Effective R-value	RSI-4.4 m^2K/W | R-24.9 $ft^2 \cdot °F \cdot h/BTU$
Embodied Carbon per m^2 of Enclosure (A1-A3)	94.49 $kgCO_2/m^2$
Biogenic Carbon per m^2 of Enclosure	0 $kgCO_2/m^2$

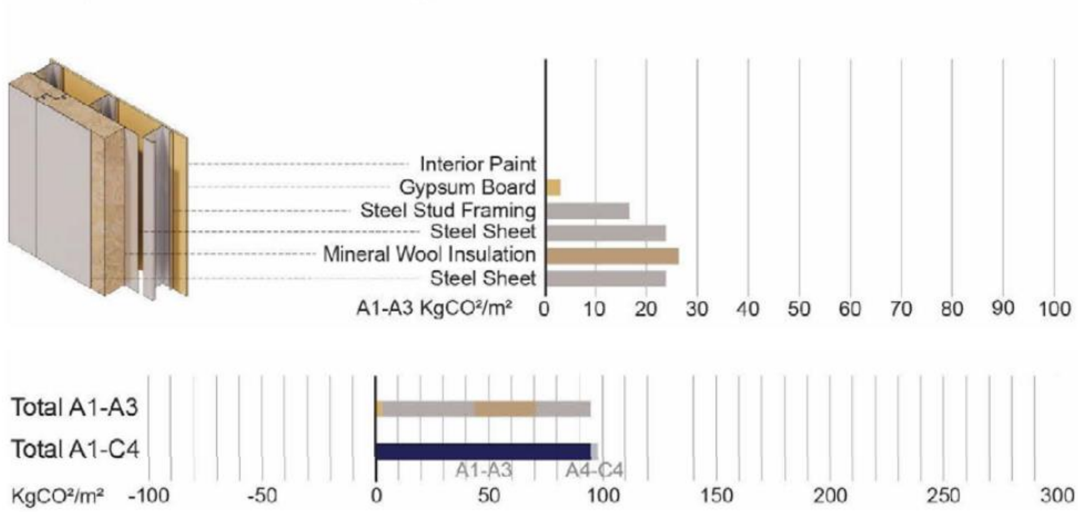


Figure 15: Typical wall assembly: Insulated Metal Panel with Mineral Wool Insulation [28]

Category	Material	Description (from EPD)	Thickness	Material Volume	Carbon Emissions (A1-A3)	% of total
Units			mm	m^3	kgCO2e	%
Finish	Interior Paint	Eggshell acrylic paint, 1294.29 kg/m3	-	0.0014	0.6	0.07%
Finish	Gypsum Board	Gypsum plaster board, regular, generic, 6.5-25 mm, 10.725 kg/m2 (for 12.5 mm), 858 kg/m3	12.7 (0.5")	0.114	26.04	3.06%
Interior finish support	Steel Stud Framing	Steel stud framing for drywall/gypsum plasterboard per sq. meter of wall area (incl. air gaps per m3), C-profile: 152.4 mm x 76.2 mm, gauge 20 (40 cm) spacing	152.4 (6")	*	158.39	18.62%
Interior Finish	Steel sheet	Steel façade panel (Metal Construction Association)	1 (0.039")	0.009	211.62	24.88%
Exterior Insulation	Exterior Insulation Mineral Wool (Semi-rigid)	Heavy density mineral wool board, 1 m2K/W, 34 mm, 4.2 kg/m2, 123.52 kg/m3, Industry average US (NAIMA)	152.4 (6")	1.37	242.18	28.48%
Exterior Finish	Steel sheet	Steel façade panel (Metal Construction Association)	1 (0.04")	0.009	211.62	24.88%
				TOTAL	**850.45**	100.0%

Figure 16: Embodied carbon emissions (A1-A3) for a 9 m^2 assembly area [28]

Lifecycle Stage		A1 to C4	A1-A3	A4-A5	B1-B5	C1-C4	A1-A3 Contribution to total
Category	Units	**Total**	Construction Materials	Transport to Site & Construction	Material Replacement & Refurbishment	Deconstruction	%
Global Warming	kg CO2e	**880.78**	850.44	7.08	8.78	14.48	96.56%
Acidification	kg SO	**3.02**	2.89	0.04	0.05	0.05	95.60%
Eutrophication	kg Ne	**0.18**	0.16	0.01	0.0028	0.01	88.71%
Ozone Depletion	kg CFC11e	**0.00002**	0.000012	0.000002	0.000001	0.0000009	77.91%
Formation of Tropospheric Ozone	kg O3e	**59.42**	56.44	1.14	0.98	0.86	94.98%
Fossil Fuel Primary Energy	MJ	**8,324.56**	7,913.47	201.28	68.36	141.45	95.06%
Biogenic Carbon Storage	kg CO2e	**0**	0	0	0	0	

Figure 17: Environmental emissions (A1-C4) for a 9 m^2 assembly area [28]

For more information on other typical external wall assemblies, please refer to the RDH report linked here.

Typical Internal Wall Assembly from Certainteed's Canadian Gypsum and Insulation Systems Manual

1-Hour Fire Resistance Rating

1-Hour Fire Design ULC U411	Fire System Details
	• Type X CertainTeed Gypsum Panels • Min. 92 mm (3-5/8"), 0.45 mm (0.018") steel studs at 610 mm (24") o.c. max. • Optional CertainTeed glass fibre insulation • Optional resilient channel • Tape and finish outer layer with CertainTeed products • Comparable assembly cUL U465

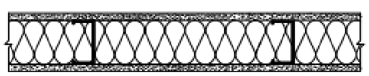
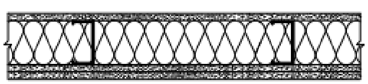
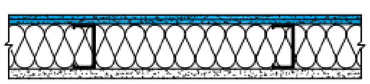
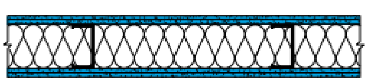
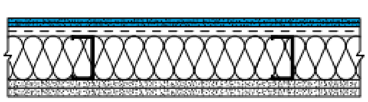
Assembly	Acoustical Details
	1 layer Type X each side 92 mm (0.45 mm) studs at 610 mm o.c.
	1 layer Type X each side 92 mm (0.45 mm) studs at 610 mm o.c. 89 mm glass fibre insulation
	1 layer Type X one side 2 layers Type X other side 92 mm (0.45 mm) studs at 610 mm o.c. 89 mm glass fibre insulation
	1 layer SilentFX® QuickCut™ Type X one side 1 layer Type X other side 92 mm (0.45 mm) studs at 610 mm o.c. 89 mm glass fibre insulation
	1 layer SilentFX® QuickCut™ Type X each side 92 mm (0.45 mm) studs at 610 mm o.c. 89 mm glass fibre insulation
	Resilient channels at 610 mm o.c. with 1 layer SilentFX® QuickCut™ Type X one side 2 layers Type X other side 92 mm (0.45 mm) studs at 610 mm o.c. 89 mm glass fibre insulation

Figure 18: Technical specifications of internal wall type ULC U411 [32]

For more information on other typical internal wall assemblies, please refer to Certainteed's Gypsum and Insulation Systems Manual.

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