Vitro
Architectural Glass

Glass & Embodied Carbon

Introduction

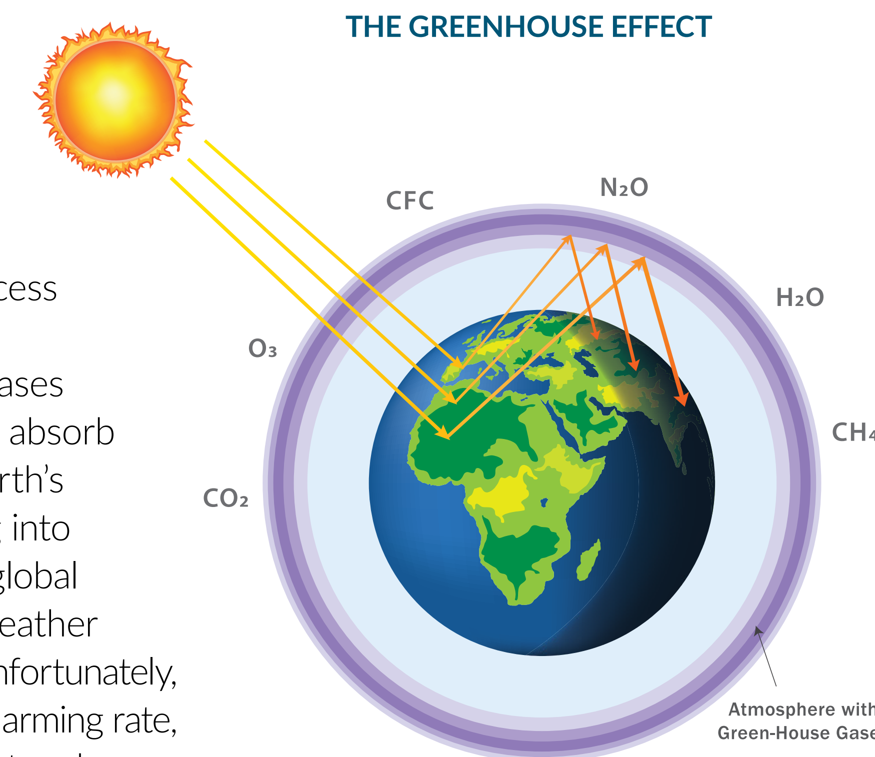
Sustainable design and construction continue to grow in importance in today's building projects. Driven by stricter building codes and standards, green building certifications, climate change concerns, strong tenant preferences and an increased focus on embodied carbon, architects and building owners are tasked with lowering their energy use levels and procuring low-carbon materials.

To best navigate this evolving landscape of carbon assessments, expectations and requirements, the following white paper goes step by step through:

- The definitions of carbon in buildings
- How glass relates to carbon
- Environmental product declaration (EPD) development
- The importance of quality and consistency in embodied carbon data
- Reducing carbon in glass manufacturing
- Building codes
- Other initiatives related to reducing carbon

COVER
John W. Olver Design Building
Amherst, MA
Products: *Solarban*® 60 Glass, *Solarban*® 70 Glass
Architect: Leers Weinzapfel Associates
Fabricator: *Vitro Certified*® Fabricator
Photographer: Ngoc X Doan Photography

Defining Carbon



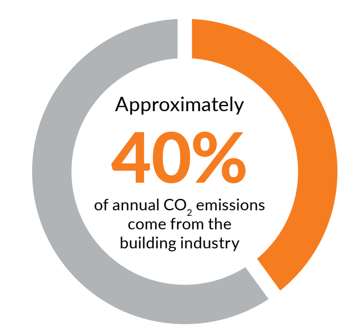
Carbon dioxide (CO_2) is the primary contributor to greenhouse gas emissions and global warming. It unnaturally warms the Earth's atmosphere by trapping heat, a process known as the greenhouse effect. When CO_2 and other greenhouse gases accumulate in the atmosphere, they absorb infrared radiation emitted by the Earth's surface, preventing it from escaping into space. This trapped heat increases global temperatures, leading to extreme weather events and ecosystem imbalances. Unfortunately, carbon levels have been rising at an alarming rate, already increasing the Earth's temperature by 34.7 degrees Fahrenheit (1.5 degrees Celsius).

With the built environment comprising approximately 40% of annual CO_2 emissions, the building industry, as a whole, is stepping up, initiating programs, policies, technology and product developments to help curb emissions.

The carbon associated with buildings is broken down into two categories: operational carbon and embodied carbon. Operational carbon is the amount of energy required to light, heat, cool, ventilate and control buildings. The quantity of operational carbon is spread out over a building's lifetime.

Embodied carbon is the amount of carbon associated with the construction of a building. This includes all the carbon extracted to manufacture the materials, products and systems that go into the building, transporting these materials, and the construction process.

While embodied carbon comprises approximately one third of all the carbon associated with buildings, the benefits of reductions in this "up front" carbon can be captured in the short term whereas operational carbon reductions take time to add up over the lifetime of the building.



Carbon & Glass

During the early stages of the sustainable building movement, the industry's focus was on developing more energy efficient products and systems.

Glass has played a key role in this effort with the development of solar control glazing technologies. Solar control glazings are designed to manage the amount of solar heat entering a building, significantly reducing indoor temperatures and the need for air conditioning. This type of glass enhances energy efficiency, leading to lower energy bills and reduced carbon emissions. It also minimizes glare from the sun, improving visual comfort for occupants, while still allowing natural light to pass through, maintaining a bright indoor environment.

In addition, some solar control glazings offer protection against harmful UV rays, preventing the fading of interior furnishings and reducing health risks. Overall, solar control glazings are a crucial component of sustainable building design, especially in warm climates where managing solar heat gain is essential.

Concretizing the energy saving values provided by glazing, Vitro Architectural Glass offers an emissions calculator to compute energy savings based on the building type, location and orientation, glass type, window-to-wall ratio and more. The calculator then breaks down all the operational values.

In recent years, the focus has shifted to embodied carbon. To measure the Green House Gas (GHG) emissions that trap heat in the earth's atmosphere, the most comprehensive metric as it relates to embodied carbon is Global Warming Potential (GWP). This value takes all the energy used to create a product and converts it into kilograms of equivalent carbon dioxide, expressed as the term "CO_2-eq."

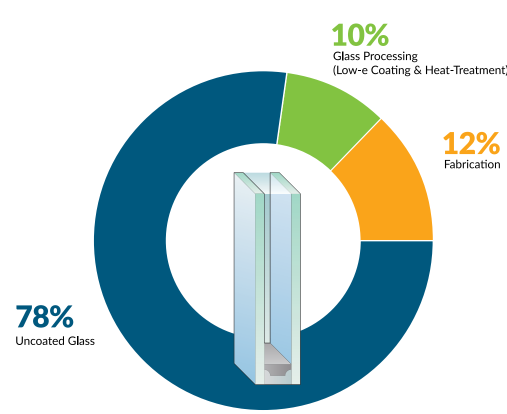
A product's calculated GWP serves as the key metric for evaluating the environmental impact of manufactured products, including glass.

How do the different components of glass production contribute to the material's GWP?

The vast majority, approximately 78% of the carbon, is in the uncoated flat glass. This is created by the energy-intensive process of melting silica, soda ash, dolomite, metal compounds and recycled cullet glass at 3,000 degrees Fahrenheit to manufacture the glass.

Of the remaining embodied carbon, approximately 12% is created by the insulating glass unit (IGU) fabrication process and 10% comes from the heat treatment process and adding energy-efficient low-e coatings.

Given these percentages, Vitro recommends using a Flat Glass EPD to evaluate carbon content since the majority of GWP for processed glass IGUs comes from flat glass. Building industry professionals then reference the GWP value contained within the EPD produced by building industry groups and individual manufacturers.



What is an EPD?

Like a nutrition label on food, EPDs are an internationally recognized label delineating the environmental impact of a product or material.

Third-party verified, EPDs are developed based upon Product Category Rules (PCRs), per American Society for Testing and Materials (ASTM), on how to conduct a life-cycle assessment (LCA). The EPD transparently reports all the environmental impacts in an LCA from raw material extraction to the final product.

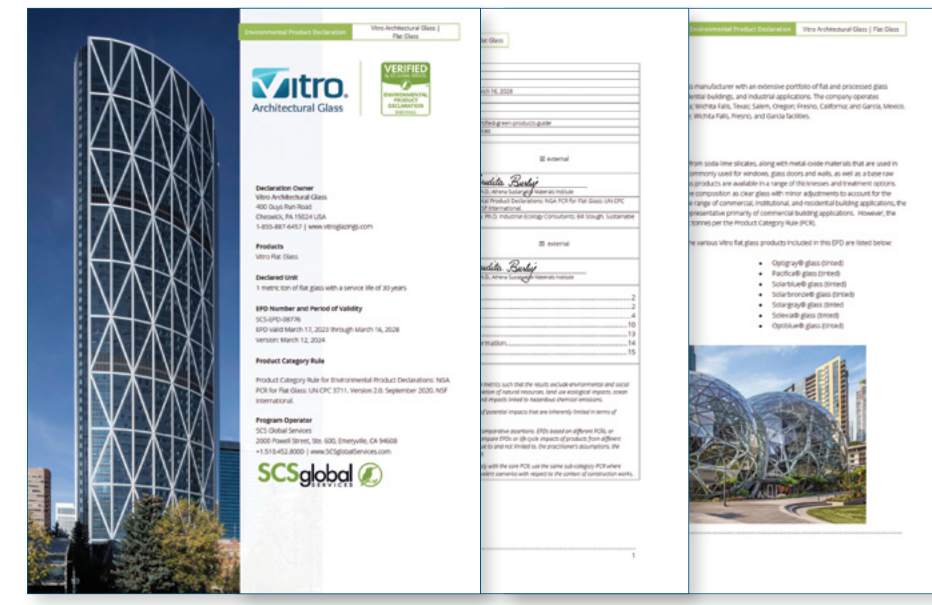
While EPDs are a valuable tool for architects evaluating the sustainable attributes of different glass products, comparing glass to other materials is not recommended.

For starters, different materials use different product category rules. Furthermore, there can be variations in the methodology, assumptions, allocation methods, data quality and assessment software tools used to compute environmental impact levels.

Even comparing North American glass manufacturers with European glass manufacturers is not so straightforward as they don't use the same PCRs, plus North America utilizes a cradle-to-gate LCA and in Europe, the LCA is cradle to grave.

According to the National Glass Association (NGA), when comparing EPDs of the same type, it is critical to ensure the following values are identical:

- PCR used
- Declared unit. A comparison of EPD results on a mass basis is insufficient. The technical performance of the specific product should be what is considered
- System boundary, i.e., use and end-of-life stage assumptions
- Data quality such as variability in data sets and broad error margins in data
- EPD methodology and assumptions



- Allocation methods
- Variability in assessment software tools used
- Program manager/program operator
- Data sources that assumptions are based on

An EPD should be product-specific vs. industry wide. In addition, Vitro recommends general EPDs vs. facility plant-specific EPDs for a number of reasons.

First, not all glass products are produced in every plant operated by a specific glass manufacturer. Consequently, a facility plant-specific EPD is not an accurate representation of that glass product.

Facility-specific EPDs also run the risk of competitors using the data to back calculate the cost structure of another manufacturer's products. To mitigate this risk, it is essential to protect sensitive cost information by providing product-specific EPDs as they provide a more generalized view of environmental impacts without revealing detailed cost structures.

The ideal situation is for the Flat Glass EPD to be used for all glass products, including windows, since the majority of the GWP for an IGU comes from the flat glass itself. This approach prevents hundreds of window makers from incurring significant costs to generate EPDs for each of their products, costs which would ultimately be passed on to consumers. Additionally, the potential error in an EPD can be significant. For example, if the error margin is ±20%, this could be as large as all the other processing steps in making an IGU combined, given that 75% to 80% of the GWP comes from flat glass manufacturing.

Consistency and Quality of Embodied Carbon Data

Back in 2017, Vitro became the first North American manufacturer to publish third-party verified EPDs for flat glass and processed glass products.

Then in 2019, the National Glass Association (NGA) published an architectural glass EPD for clear, low-iron and tinted flat glass produced by four member companies of the NGA's Forming Committee, including Vitro. Its findings suggested an industry average GWP of 1,430 kilograms for comparable products.

In 2024, Vitro updated its EPD for its flat glass products and reported an even lower GWP of just 1,240 kilograms of CO_2 equivalent. This is 13% lower than the NGA's industry standard.

This lower GWP value places Vitro in the U.S. General Services Administration's (GSA) top 20% "Most Preferred" low embodied carbon (LEC) material category.

Unlike many EPDs which are only based upon 12 months of data, Vitro provided 24 months of data for their latest third-party, verified EPD.

Another distinction is that with some exceptions, EPDs are usually not applicable to all manufacturer's plants **However, in Vitro's case, the EPD applies to all Vitro products manufactured at all Vitro plants all the time.**

Lowering Carbon in Glass Manufacturing

As part of the federal government's focus on lowering emissions, this new set of LEC standards applies to three other building product types in addition to glass.

While some materials are struggling with sacrificing quality in order to meet LEC decarbonization requirements, this has not been the case with Vitro. The company's R&D team has thoughtfully applied carbon reduction measures in the glass production process with no compromise to the glass' composition, characteristics, clarity and strength.

The most intense application of energy/carbon in the glass manufacturing process is melting the glass. Consequently, Vitro has focused its efforts on making its burning and melting operations as energy efficient as possible.

These strategies include:

- Reducing variability of melting temperatures and fuel consumption through furnace control systems
- Adding new low-NOx burners to all Vitro plants
- Using variable frequency drives on cooling fans to reduce energy use
- Converting all facility lighting to LED, effectively reducing electric consumption by as much as 80% as compared to incandescent lighting

The most intense application of energy/carbon in the glass manufacturing process is melting the glass.

Lowering Carbon in Glass Manufacturing (Cont.)

- Using oxy-fuel technology at three U.S. plant locations to reduce energy consumption in glass melting furnaces by as much as 20% and cut greenhouse gas emissions in half.
- Switching from gas to electricity in key processing areas.

As manufacturers work to bring down embodied carbon levels in their products, architects and building owners will increasingly be looking for those options to help comply with stricter building codes.

A Federal-State Buy Clean Partnership with 13 states seals a commitment to prioritize efforts that support the procurement of lower-carbon infrastructure materials in state-funded projects. So far, Washington, Oregon, Minnesota and Colorado have already signed related legislation into law, and other partnership states include California, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, New Jersey, and New York.

California and New York have already been aggressively pursuing carbon goals through the CalGreen Building Standards Code and Local Law 97.

Recent updates to CalGreen have raised the stakes on embodied carbon with stricter requirements applying to non-residential developments over 100,000 square feet and school constructions exceeding 50,000 square feet. Of the three pathways to compliance, one requires building life-cycle analysis demonstrating a 10% reduction in carbon emissions compared to a baseline project design of a similar construction type. And another prescriptive pathway limits the GWP of building materials based on Buy Clean California criteria.

Meanwhile, New York's Local Law 97 requires a reduction in greenhouse gas emissions of 40% by 2024, compared to 2005 levels, for a single building exceeding 25,000 gross square feet and two or more buildings on the same tax lot that together exceed 50,000 square feet.

Other Initiatives

As the EPA rolls out its LEC rating system, their ultimate goal is to implement a tiered rating system with an online, public registry of certified construction materials and products similar to the successful Energy Star program for residential windows.

In other EPA news, the NGA recently received a $2.1 million grant from the U.S. Inflation Reduction Act (IRA) funding. The NGA plans to invest in the availability and quality of EPDs for architectural glass, bolster environmental transparency and support efforts to reduce embodied emissions in the construction industry.

The grant will also enable the NGA to collect regionalized life-cycle inventory data for flat glass, develop a tool to generate EPDs and streamline the creation of processed glass EPDs and provide support to glass fabricators for processed glass EPDs. The NGA also plans to collect end-of-life life-cycle assessment data to better understand glass recycling and its environmental impacts.

Vitro is currently monitoring and participating in all these endeavors in addition to the development of the EC3 tool for architectural glass. Spearheaded by the non-profit Building Transparency, this calculator will help architects and other stakeholders benchmark, assess and ultimately reduce embodied carbon levels in building products, including glass.

Moving Forward

It's an exciting time for the glass and building industry. Interest in sustainable design will continue to grow as will technologies, programs, regulations and codes.

It will be in architects', owners' and other stakeholders' best interests to stay abreast of the latest changes and developments.

Vitro Architectural Glass will continue to cover the latest developments, serving as an invaluable industry resource with its Glass Education Center.

vitroglazings.com
1-855-VTRO-GLS (887-6457)

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