

Raw Material Selection as Catalyst for Sustainable Glass Manufacturing

*At Imerys Performance Minerals Americas,
We're not just transforming minerals.
We're transforming possibilities.*

AGENDA

September, 2026 | Glass Problems

- Partnering with Sustainable Raw Material Suppliers
- Breaking down sources of Glass carbon emissions
- Exploring Chemical bottlenecks
- Mineral Spotlights
- Raw material impacts on Process Energy requirements



The Circular Economy and Climate Change are sustainability focuses of the Glass Industry

Recycled Content

According to the Glass Packaging Institute, energy costs drop by approx. 2 –3% for each additional 10% of cullet used in manufacturing.

Manufacturing Waste Reduction

Improving manufacturing processes to reduce and recover waste

Carbon Reduction

Glass manufacturing is an energy intensive process, with a carbon footprint of 1 -2.5 kg CO₂e/kg produced



Reduce energy use by 20% over a baseline year of 2018



Almost all furnaces converted to oxy-fuel firing furnaces to reduce exhaust gas and carbon emissions



Four decarbonization levers to achieve approved climate reduction Science-based Target



Imerys is committed to reducing our emissions & impacts for our customers

The Group achieved the highest possible CDP performance score in 2024, attaining **Level A**. This top-tier rating signifies **leadership in transparency and performance**, placing the Group among the most responsible companies globally on climate change issues.

ESG OBJECTIVES

Caring for our planet



Climate Change

Reduce Group **Scope 1 & 2** greenhouse gas emissions (tCO2eq) by 42% by the end of 2030 from 2021 base year ; compatible with a 1.5 °C trajectory

Long-term target : -42% by 2030

Reduce Group **Scope 3⁽⁶⁾** greenhouse gas emissions (tCO2eq) by 25% by the end of 2030 from 2021 base year

Long-term target : -25% by 2030

SCOPE 1 & 2 EMISSIONS

Scope 1 & 2 emissions decreased by 28% vs 2021, mainly thanks to following decarbonization levers: energy efficiency measures, substitution of emissions-intensive fossil fuels with biofuels or natural gas when biomass is unavailable, as well as a Group-wide program dedicated to the purchase of low-carbon and renewable electricity.

-28% vs 2021



SCOPE 3 EMISSIONS

Scope 3 increased by 5% vs 2023 as a result of **significant monitoring improvements**, yielding higher GHG emissions for certain scope 3 categories, particularly upstream and downstream transportation and distribution. But still a **reduction of 22% vs 2021 baseline**.

-22 % vs 2021



IMPACTS

Upstream transportation represents up to 10% of total energy consumption in glass manufacturing.

Effective decarbonization requires a holistic lifecycle approach, prioritizing regional, low-logistics mineral assets over those with high transport mileage.

Utilizing local, "near-mine" resources minimizes the logistical footprint and easily offsets potential chemical adjustments required for native trace elements.

SustainAgility Solutions Assessment

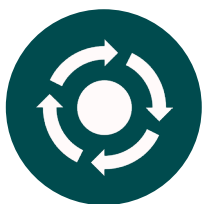


Growing with our Customers *Portfolio sustainability*

Market Trends



Lifecycle



Multi-criteria



Our approach to measuring sustainable solutions

Measuring sustainable solutions

Imerys' ambition is to proactively steer the overall product and project portfolios towards improved sustainability performance and sustainable solutions.

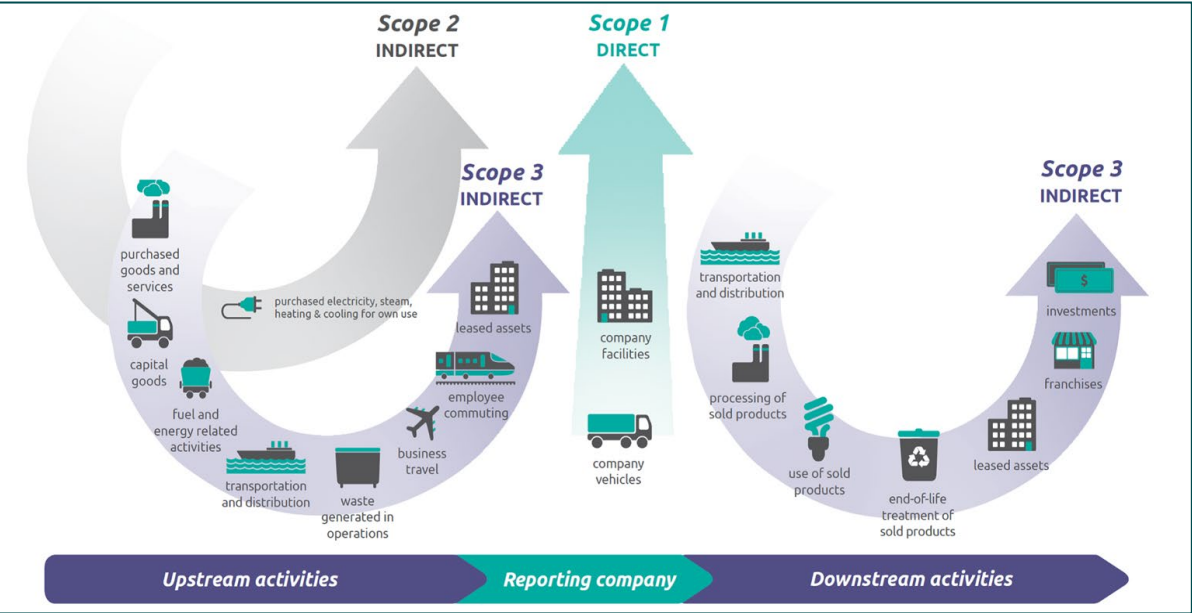
Imerys has developed a methodology to measure the sustainability profile of its solutions. This methodology is aligned with :

- WBCSD framework for PSA
- Consistent with **ISO Standards** for LCA
- Based on **quantitative** & **qualitative** indicators
- Fully **auditable** process & data

Scope 3 emissions can have a hidden impact

For most companies, Scope 3 represents the largest portion of their company’s carbon footprint

Scope 3 includes both upstream and downstream transportation



Imerys focuses on seven levers to reduce emissions from scope 3

Reduction Levers
1. Supplier Specific EF Integration
2. Alternative/Lower Carbon Products
3. Optimized Consumption or Logistics
4. Local Sourcing
5. Replace Product with a Service
6. Modal Shift
7. Fuel Change & Electrification

In 2022, direct and indirect greenhouse gas emissions from transportation accounted for 29% of the total U.S. greenhouse gas emissions, making it the third largest contributor of U.S. greenhouse gas emissions. This includes 23% from medium- and heavy-duty trucks, but only 2% is from rail.

Deconstructing Glass Carbon

True net -zero manufacturing requires a single, unified material strategy targeting three carbon areas simultaneously.

Scope 1 Emissions

Direct emissions from glass manufacturing



Raw Material Chemistry

~15% to 18% of lifecycle

CO2 released strictly from thermal decomposition of carbonate raw materials during melting phase.



Process Energy

~40% to 50% of lifecycle

Emissions generated via fossil fuel combustion or grid power required to hit melting temperatures.

Scope 3 Emissions

Indirect upstream emissions



Logistics & Upstream

~40% of lifecycle Cradle-to-gate impact of mining, milling, processing, and shipping logistics.

The Calcination Bottleneck

25%
OF DIRECT FURNACE EMISSIONS

The Limit of Downstream Engineering

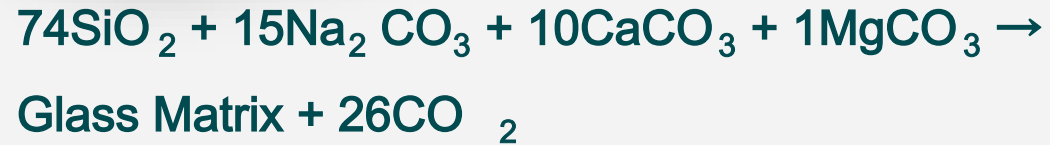
Direct process emissions from carbonate decomposition are a function of chemical stoichiometry, completely independent of furnace fuel or electrification.

Calcium carbonate (CaCO_3) undergoes rapid endothermic decomposition between 900 °C and 1000 °C, releasing **44% of its mineral mass** as gaseous CO_2 .

Even under 100% green electrification, a traditional carbonate batch will still release **200 to 250 kg** of chemically bound CO_2 per ton of glass.

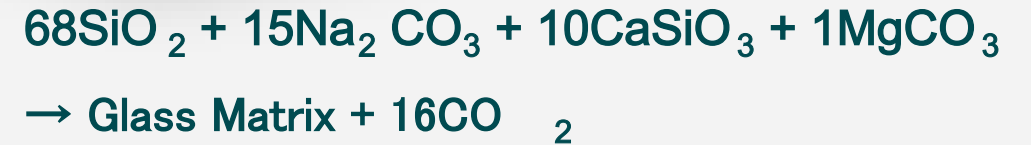
Leveraging Stoichiometric Solutions

Traditional Carbonate Based Reaction



Standard batch layout carries massive geological carbon dead-weight directly into the furnace, requiring calcination energy before dissolution begins.

Wollastonite -Modified Silicate Reaction



Substituting calcium carbonate with a naturally occurring Calcium Silicate (CaSiO_3), Wollastonite, yields an immediate, absolute **25% reduction in process emissions** by delivering carbon-free oxides

Direct Carbon contributions to Glass Batch

Direct CO₂ off gassing typically results in ~200-250kg CO₂e/ ton of glass

Oxide	E-Glass Fiber (wt%)	Float Glass (wt %)	Common Raw Material	Carbonate Mineral CO ₂ Contribution Factor	CO ₂ Contribution (kg CO ₂ / ton glass)
SiO ₂ (Silicon Dioxide)	52.0 – 56.0%	70.0 – 74.0%	Quartz Sand	Carbon Free	N/A
Al ₂ O ₃ (Aluminium Oxide)	12.0 – 16.0%	0.1 – 2.0%	Kaolinite	Carbon Free	N/A
CaO (Calcium Oxide)	16.0 – 25.0%	7.0 – 12.0%	Calcium Carbonate	0.78 kg CO ₂ / kg CaO	60 - 200
Na ₂ O (Sodium Oxide)	0.0 – 0.8%	12.0 – 15.0%	Soda Ash	0.71 kg CO ₂ / kg Na ₂ O	0 - 105
MgO (Magnesium Oxide)	0.4 – 5.0%	3.5 – 5.0%	Magnesium Carbonate/Dolomite	1.09 kg CO ₂ / kg MgO	0 - 55

Hidden CO₂ Burdens on an Oxide Basis

Target Oxide	Cation	Traditional Source Mineral	Chemical Burden (kg CO ₂ /Kg Oxide)	Alternative Source	CO ₂ Savings & Thermodynamic Lever
CaO	Ca ²⁺	Limestone (CaCO ₃)	0.78 kg CO ₂ / kg CaO	Wollastonite (CaSiO ₃)	Chemical CO ₂ Elimination
MgO	Mg ²⁺	Magnesium Carbonate (MgCO ₃)	1.09 kg CO ₂ / kg MgO	Talc (Mg ₃ Si ₄ O ₁₀ (OH) ₂)	Chemical CO ₂ Elimination
Na ₂ O	Na ⁺	Soda Ash (Na ₂ CO ₃)	0.71 kg CO ₂ / kg Na ₂ O	Perlite (Amorphous Sodium Silicate Flux)	Chemical CO ₂ Elimination
SiO ₂	Si ⁴⁺	Silica Sand (SiO ₂)	<i>(Carbon -Free)</i>	Perlite (Glassy Amorphous Silicate)	Process Energy CO ₂ Reduction
Al ₂ O ₃	Al ³⁺	Kaolinite Clay (Al ₂ Si ₂ O ₅ (OH) ₄)	<i>(Carbon -Free)</i>	Anorthosite (CaAl ₂ Si ₂ O ₈)	Process Energy CO ₂ Reduction

Wollastonite: Eliminator of Chemical CO₂

Wollastonite is a naturally occurring calcium metasilicate with the chemical formula CaSiO_3 .

CARBON FREE CALCIUM

Leveraging the silicate composition of Wollastonite, we can introduce essential Ca^{2+} ions while avoiding the 42 wt% CO_2 release associated with calcium carbonate.

ENDOTHERMIC ENERGY AVOIDANCE

ACCELERATES BATCH MELTING

REDUCES EUTECTIC TEMPERATURE

Wollastonite



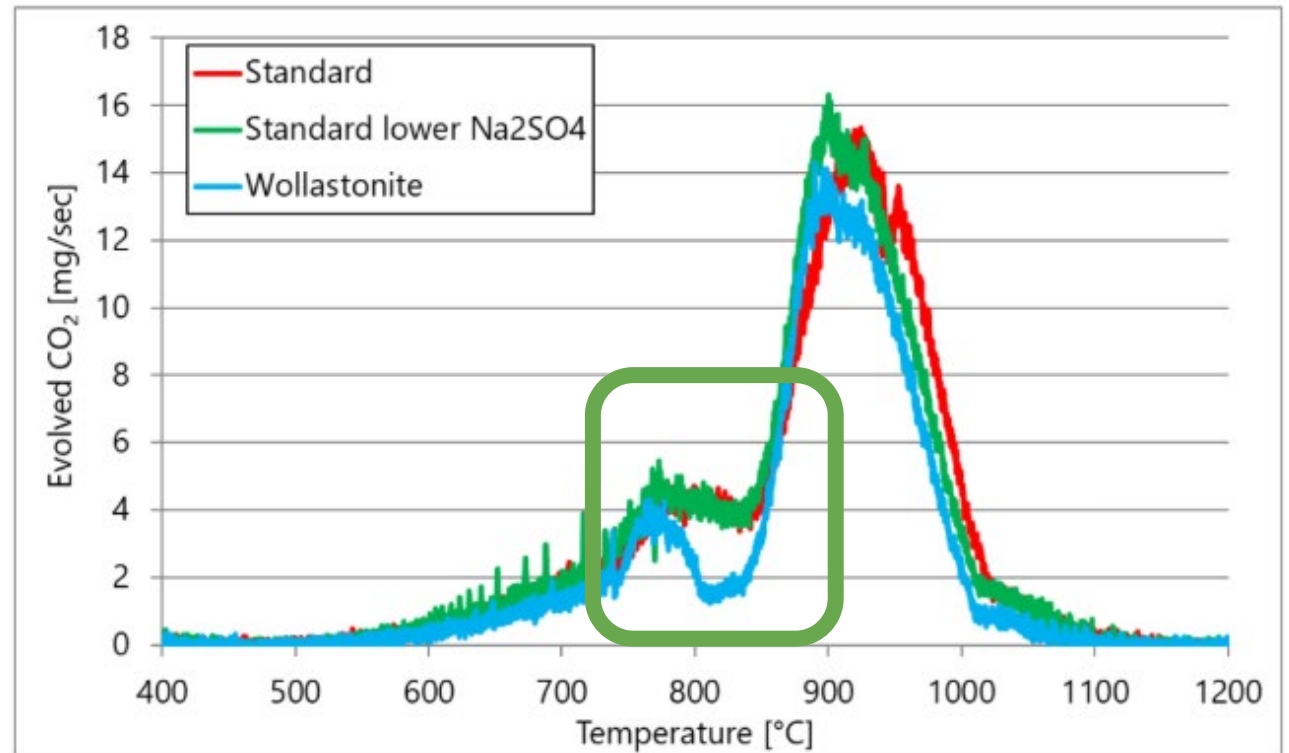
Case Study: Wollastonite based formula CO₂ savings

This graph shows the evolution of CO₂ during glass batch melting.

The three lines compare two typical carbonate based float glass formulas, with a formula utilizing NYAD M100 wollastonite.

These data show the lack of CO₂ evolution due to carbonate calcination between 800 –850 °C.

The removal of this peak results in a total reduction of CO₂ evolution of 20% in the wollastonite bearing batch vs a traditional carbonate batch.



20% Reduction in batch CO₂ evolution

Perlite - Amorphous Silica to Reduce Energy of Melting

Perlite is an amorphous silica capable of being expanded to low densities, making it an ideal choice for a wide variety of end uses from cosmetics to construction

#1 World leading supplier of perlite

Naturally Occurring Amorphous Silica

Perlite, a naturally occurring volcanic rock, possesses an amorphous silica matrix that closely mirrors many glass chemistries. This composition makes it an excellent raw material for enhancing melt dynamics.

ELIMINATE CRYSTAL BREAKDOWN

ACCELERATE SILICA MELT

HOMOGENIZE MELT CHARACTERISTICS

Perlite



Raw Material Impacts on Melting Dynamics

Mechanical Decrepitation and Dust Carry -Over:

Sedimentary minerals hold fluid inclusions of water, CO₂, or brine. In a 1400 °C+ furnace, these fluids turn into high - pressure supercritical steam, causing the mineral lattice to shatter into micro -fragments. Precise powder engineering must be employed to mitigate these detrimental effects.

Gas-Entrapment Cooling:

The CO₂ released during carbonate calcination creates an insulating foam layer that scatters radiative furnace heat, obstructing the heat penetration. Eliminating high off -gassing raw materials reduces the challenges posed by foam evolution and improves heat flow dynamics.

Heterogeneous Dissolution:

Utilizing a pre -existing silicate framework avoids the formation of segregated, high -density melt phases. The primary liquid phase remains homogeneous and keeps the remaining silica sand evenly distributed and wetted, accelerating the dissolution kinetics at lower overall furnace temperatures.

Holistic Decarbonization Future

Re-Engineer Chemistry :

Systematically replace traditional carbonates with silicate -based minerals such as wollastonite to cut process emissions by up to 25%.

Optimize Process Energy:

Leverage anhydrous/amorphous materials such as perlite to bypass endothermic phase changes, lowering fuel consumption and kinetic barriers.

Audit Logistics and Scope 3:

Evaluate procurement through full cradle -to-gate life cycle assessment, anchoring supply lines around low -logistics, regional mining assets.



Thank you for your attention

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