

Strengthening Sustainability *in the Glass Industry*



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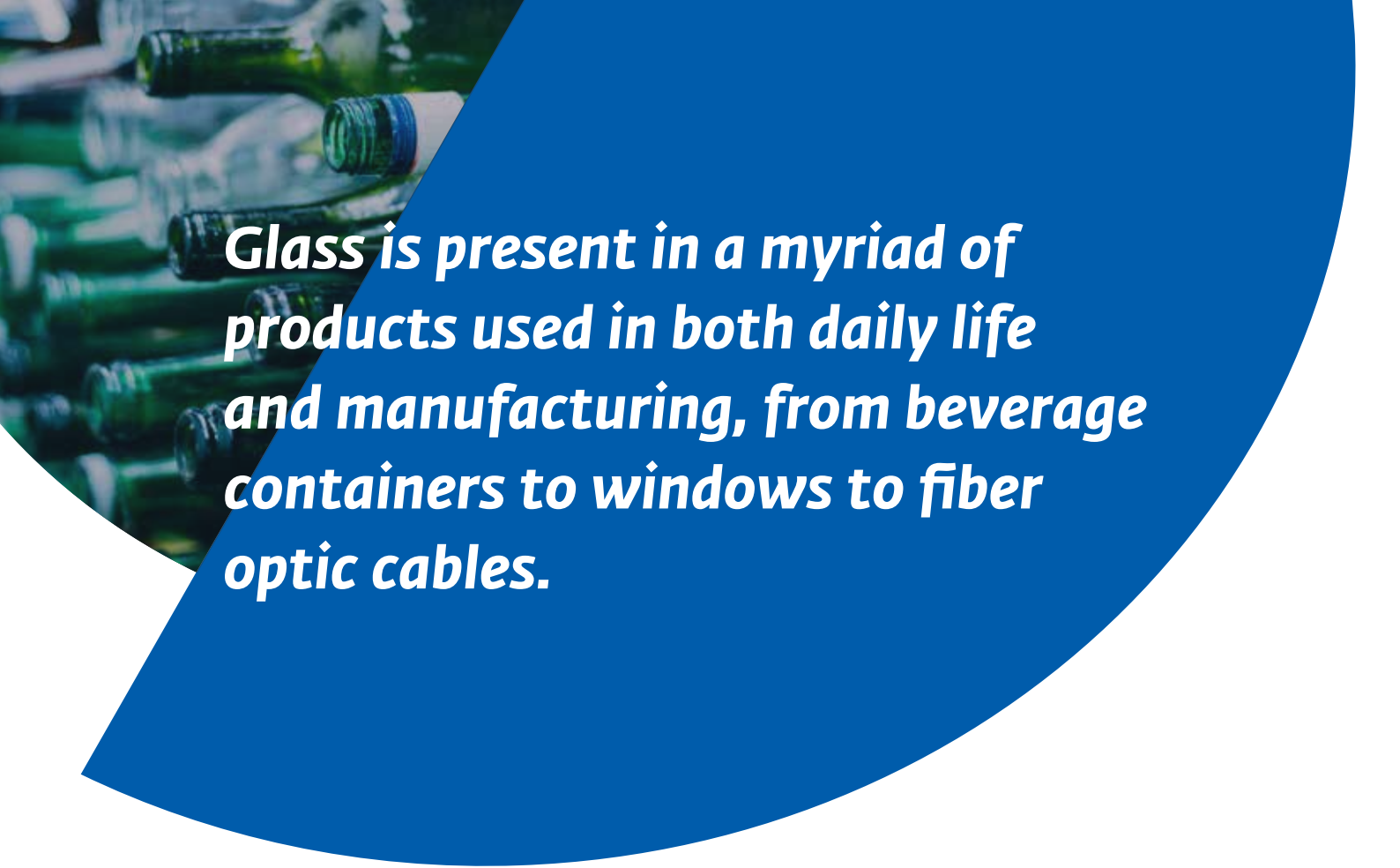
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Growing global concerns over climate change are putting an increasing focus on sustainability. This report is part of an occasional series on sustainability in industry which examines the opportunities and challenges facing various industrial sectors and the role that the International Finance Corporation can play to support their efforts and contribute to a greener planet.



Glass is present in a myriad of products used in both daily life and manufacturing, from beverage containers to windows to fiber optic cables.

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Its many properties and affordable cost make it an essential material for development, whether in the construction of houses and high rises where people live and work or for use in industries such as agribusiness and automaking.

Glass is also attractive because of its sustainability—a growing consideration for countries, companies, and consumers as the world seeks to address climate change. Because glass products are 100-percent recyclable, the industry lends itself well to the circular economy. At the same time, glass can be used to help

other industries become more energy-efficient and sustainable.

The industry's own high energy use remains a challenge, although in the last few decades companies have introduced innovations in glass production processes to reduce waste and boost efficiency. With support from the International Finance Corporation (IFC) and the private sector, the industry can continue to improve its energy efficiency while meeting increased demand for sustainable glass products.

Sector Background

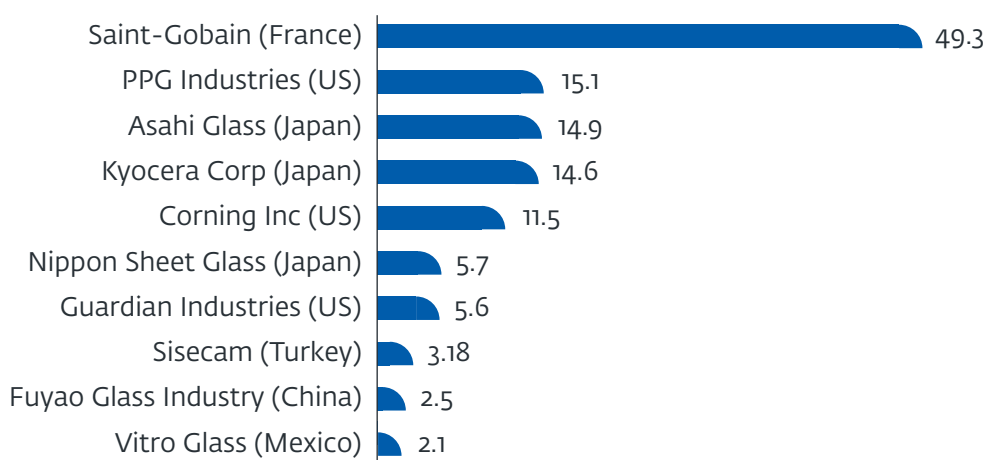
Glass is among the world's most important and oldest base materials, dating back 7,000 years to the Egyptians. Today, it is near ubiquitous, found in buildings, transportation vehicles, containers, and scientific and medical products, as well as telecommunications equipment and electronics. Many experts believe glass has yet to realize its full potential in terms of diverse uses.

Production of glass requires very high temperatures, of about 1,600°C, to melt several minerals, including silica, the main ingredient, in the form of sand; soda ash; and limestone. These raw materials are plentiful and cheap, but the costs and challenges of transporting them and the end products mean that glass manufacturing tends to

be a localized industry, with factories located near their end markets. Some companies have emerged to dominate specialized niches, however, such as O-I Glass, Inc. of the United States, which produces container glass, and France's Saint-Gobain, a key player in flat glass. In terms of overall volume, China ranks at the top of the global market, due to the size of its domestic market and its industry's cost competitiveness.

Glass's low cost and varied properties—durability, thermal and chemical tolerance, transparency, and recyclability—make it a popular material for use in numerous products across a range of industries. In 2019, the world consumed more than 194 million tons of glass, and demand is forecast to increase to 256 million tons

Leading Players in Glass, by Revenue (US\$ blns), 2019



Source: Garside 2020.

by 2027, representing compounded annual growth of 3.5 percent.¹ This would be equivalent to 20,000 km² of window glass, or more than half the size of Belgium. Container glass (45 percent) and specialty glass (33 percent) accounted for the largest share of glass production in 2018.² Main drivers of growth include increased use of flat glass in the construction industry as more urban centers spring up in emerging economies; growing demand for bottles linked to rising disposable incomes and consumer consumption of beer and other beverages; and surging production of screens and panels for newer technologies such as cellular phones and solar panels.

Glass also plays a major role in development, providing windows for houses that improve people's lives and flat glass for buildings and cars that are integral to urbanization.

The glass industry generates jobs, and its products can help a country's economy move up the production value chain, for example, with glass containers facilitating agribusiness. As global concerns over climate change increase the focus on sustainability, the glass industry also has a key role to play in terms of strengthening sustainability of its own products and contributing to the "greening" of other industries.

Sustainability

The glass industry has become more productive, energy-efficient, and sustainable over the past few decades in response to market conditions. Amid the 1970s oil embargo and subsequent fuel shortages and economic recession, the industry boosted its energy efficiency and developed innovative products that improved energy use in buildings and cars. The European Union has set a timetable for the reduction of greenhouse gas emissions, with a 30 percent-reduction target from 1990 levels by 2030 and 40 percent by 2040, culminating in "net zero" by

2050.³ Many other organizations and governments around the world have set guidelines and adopted policies with the same aim. Today, glass manufacturers are contributing to sustainability in their own and other industries in several ways.

Recyclability

Glass is a fully recyclable material that can be reprocessed and reused in a closed loop continuously, making it a prime candidate for participation in the circular economy. Glass's recyclability allows for significant savings in raw

materials, rare natural resources, and energy.

In the recycling process, used glass is crushed to form cullet, which melts at a lower temperature and uses approximately 40 percent less energy than is needed to make glass from raw materials. Recyclability also helps reduce the amount of solid waste that goes into landfill.

The recycled glass market is expanding quickly, with production forecast to reach \$5.5 billion by 2025 from \$3.5 billion in 2017.⁴ Recycled glass comes in the form of cullet, glass powder, or crushed glass. Government regulations in the EU are helping to drive growth in the recycled-glass market; Germany leads European nations in recycling and is successful in recovering and reusing about 70 percent of waste generated (including glass) annually due to supportive government regulations.⁵

The biggest constraint to growth in the recycled-glass market is lack of an established ecosystem, such as government support and infrastructure, to enable efficient collection. Industry players and offtakers, such as large beverage companies and other major brands selling fast-moving consumer goods, could greatly help address this challenge by increasing their use of recycled glass bottles. Additional barriers to growth include glass

breakage and contamination with other materials at recovery facilities, which result in increased processing costs. Moreover, procuring cullet in a clean, furnace-ready form requires a lot of processing that is usually done inefficiently, complicating the recycling process.

Reduced energy use and emissions

Energy-efficiency measures implemented by the industry, including the increased use of cullet, have directly contributed to a reduction in greenhouse emissions over the last few decades. The industry has decreased its emissions per output considerably, with a 69-percent reduction of CO₂ per ton of melted glass between 1960 and 2010.⁶ The EU flat glass industry, meanwhile, reduced its CO₂ emissions per ton of glass by more than 40 percent between 1990 and 2018.⁷ However, additional reductions have been realized at a slower pace as marginal gains become more difficult.

Energy management in other sectors

The glass industry has contributed to efficient energy use and savings in various sectors that rely on its products.

Building and construction

According to the United Nations Environment Programme (UNEP),

the building and construction sector accounted for 36 percent of global energy use and 39 percent of energy- and process-related CO₂ emissions in 2018.⁸ The energy savings potential for buildings is enormous, with glass playing a critical role in the construction of green residential and commercial buildings. Flat glass used for windows, doors, and roofs can help retain heat inside a room or prevent excess heat from entering a room, reducing energy consumption from heating and cooling systems. Glazed glass, especially triple-glazed glass, can enhance these capabilities. The transparency of clear flat glass allows sunlight transmission while coated or tinted glass can inhibit such transmission, as well as heat transmission; these qualities can help reduce electricity use for artificial lights and air conditioners.

■ Renewable energy

Demand is growing around the world for solar energy applications such as solar panels. The global solar energy market is projected to reach \$223 billion by 2026 from \$52.5 billion in 2018.⁹ Thin glass is widely used in solar modules as it provides better light transmission of solar radiation and increases panels' efficiency rate. Glass fiber is used for making wind turbine blades, which help to

convert wind's kinetic energy into electricity. The global wind turbine market is forecast to grow by an annual compounded rate of 5.3 percent between 2019 and 2025, when global revenue is projected to reach \$123 billion.¹⁰

■ Transport

Glass fiber is mixed with composites to reinforce automotive, aviation, and other transport vehicle components, reducing the weight of the vehicles, and consequently, their fuel consumption. Packaging. Innovations in the design of glass packaging, such as through reductions in the weight and size of bottles, help save raw materials and reduce carbon emissions from production and transportation. Current glass packaging is approximately 50 percent lighter than in the past. In 2013, U.K. packaging company Rawlings worked with O-I Glass to develop a lightweight glass bottle branded "ethical glass" for Belu mineral water. The glass bottles are 20 grams lighter, saving about 850,000 kilograms of glass (equivalent to 2.1 million wine bottles) and contributing to an 11-percent reduction in carbon emissions annually.¹¹

BOX I: *Glass for Every Function*

The glass industry can be categorized into four main subsectors. These subsectors differ in terms of the manufacturing process, the end products and applications, and the target markets, but they all involve melding raw materials into glass.

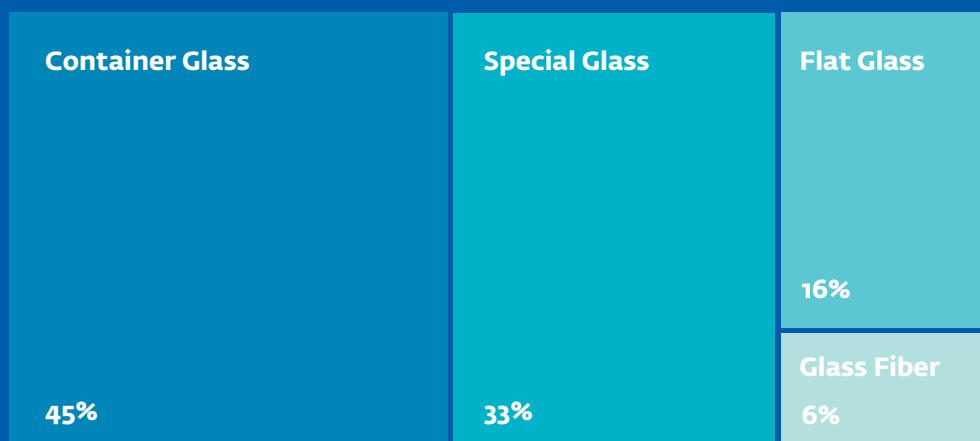
Flat Glass: Used in the buildings and construction sector (windows and facades, partitions, staircases), automotive industry (sunroofs, windcreens, rear lights, and rearview and side mirrors), and solar energy appliances (photovoltaic and solar thermal panels), among others.

Container Glass: Used for a variety of glass packaging materials, including for beverages, food, pharmaceuticals, and cosmetics.

Glassware: Mainly comprised of domestic glasses used for tableware, cookware, and decorative products such as bowls, vases, plates, and ornaments.

Other: Comprised of (i) **special glass**, which includes glass tubes, laboratory equipment, lighting glass, ceramics, heat-resistant glass, and optical glass; and (ii) continuous filament **glass fiber**, which is utilized in manufacturing composite materials, such as weight-lightening reinforcement components.

Distribution of Glass Production by Type in 2018



Source: Garside 2021.

Challenges & Opportunities

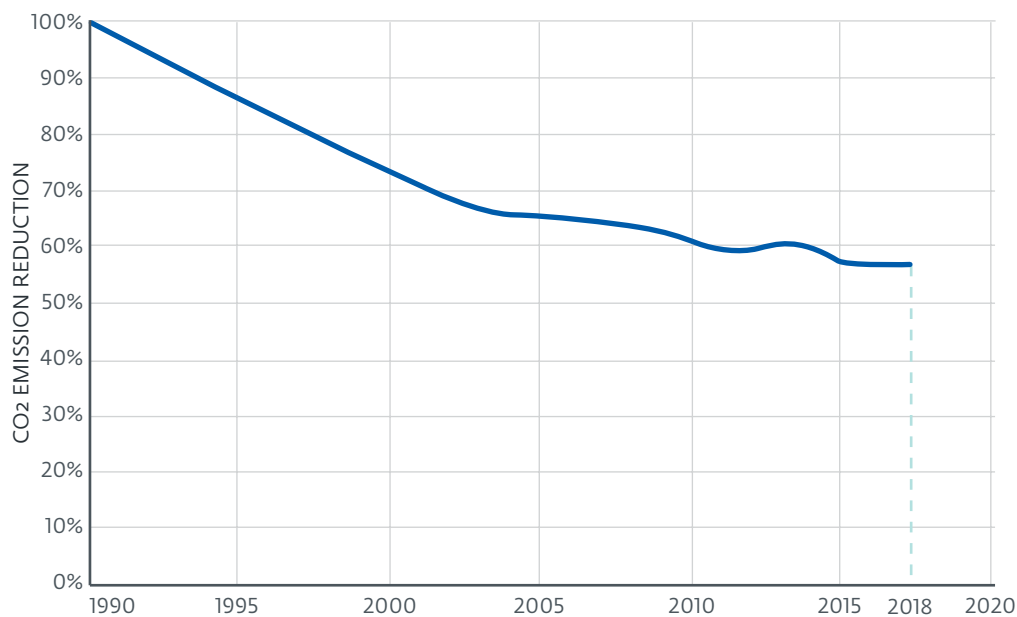
Despite its advances in and contributions to sustainability, the glass industry faces a number of challenges. Glass manufacturing (melting and refining) requires high energy use, which involves significant economic and environmental costs. The glassmaking process emits combustion by-products, including sulphur oxides (SO_x) and nitrogen oxides (NO_x), and carbon dioxide (CO₂), a main contributor to global warming.

The actual amount of greenhouse gases (GHG) emitted is directly linked to the type of glass produced, the type and amount of fossil fuels used, the manufacturing process's energy efficiency, and the use (or not) of recycled glass, or cullet. Glass-melting

furnaces contribute 80 to 90 percent of total air-pollutant emissions from a glass production facility; furnace emissions contain particulate matter and may also contain low levels of metals including lead and cadmium.¹²

To reduce emissions, the industry is seeking to optimize the manufacturing process and exploring possible solutions such as carbon capture and storage. Europe has been investing in both product and process innovations for years through research and development initiatives, such as low carbon technologies for flat glass melting. Research is also ongoing into innovations that shift

Average CO₂ Emissions per Ton of Float Glass Produced in the EU



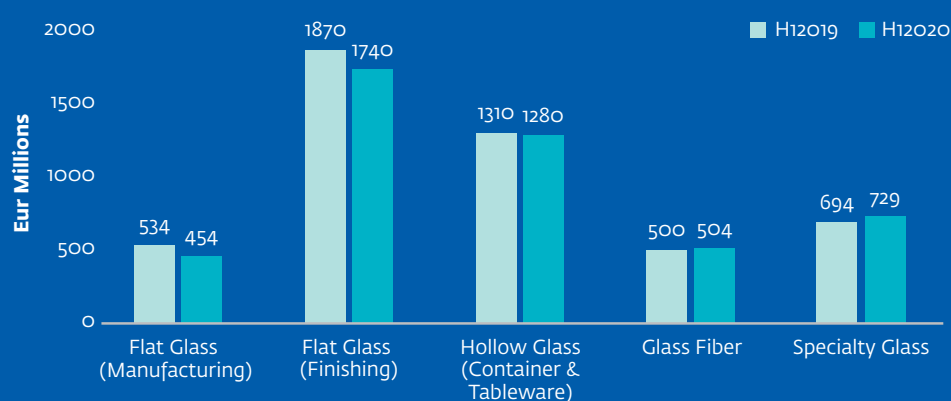
Source: Glass for Europe 2020.

BOX II: **COVID-19 Impact on the Glass Sector**

The COVID-19 pandemic has had a mixed impact on the glass industry, dampening demand in the short term but also presenting unexpected growth opportunities. Overall demand for glass and glass products, including flat glass, container glass, and glassware, declined in the first half of 2020, as lockdown measures aimed at curbing the pandemic crimped spending. Many glass manufacturers have experienced business disruptions, including reductions in their capacity utilization rate, cancellation of orders, shutdown of manufacturing operations, and job losses. Facing declines in revenues and profits, some companies scaled back capital expenditure investments and struggled with increasing amounts of bad debt; others faced solvency issues.

According to data from German industry association BV Glas, glass industry

Reported Glass Revenues in Europe, H12019 and H12020



Source: BV Glas 2020.

revenues in Europe declined year-over-year by 4.1 percent in the first six months of 2020 to EUR 4.70 bn from EUR 4.90 bn for the same period in 2019. Domestic and foreign revenues declined by 5.7 and 1.8 percent, respectively. The flat glass segment was severely affected by decreases in car production while hollow glass was impacted by the reduced demand for tableware glass.^a

The pandemic has generated opportunities for other glass producers. With more people eating at home because of lockdowns, demand for food and drink containers has surged. (Ninety percent of glass containers are used for food and beverage packaging.^b) Hospitals and pharmacies, meanwhile, have seen increased demand for medicine bottles and glass vials, including those needed for administering the COVID-19 vaccine—a campaign that is taking place on a global scale over at least the next two years.

a. Glass on Web 2020.
b. Business Wire 2020.

to carbon-neutral energy sources such as bio-gas, hydrogen, and electricity (generated from renewable sources). European container glass manufacturers are working on the “furnace of the future,” which will be the world’s first large-scale hybrid electric furnace to run on 80 percent green electricity and is scheduled to be built by 2022.¹³

Another way to minimize emissions in the production process is through the adoption of electric heating technologies. With an insulating layer of batch, or starting material, covering the surface of the glass in a continuous vertical melting process, a well-designed, all-electric melter can have a thermal efficiency of 85 percent, close to twice that of even the most energy-efficient fuel-fired furnaces.¹⁴ But major

transformations in manufacturing process, infrastructure, feedstock, and science and technology are still required to cut CO₂ emissions on a much larger scale.

Energy costs can also be significant. In Europe, energy costs are approximately 22 percent of production costs while labor costs are about 16 percent.¹⁵

Another challenge facing the glass sector is the increasing difficulty in sourcing certain raw materials, especially rare earth resources, leading to intense competition internationally. The industry also registers higher average incidences of injury and illness than the overall manufacturing sector, according to the International Labour Organization (ILO).¹⁶

IFC Role

The International Finance Corporation provides capital and advisory services to glass manufacturers to help them achieve optimal production and operations, including moving up the production value chain, carrying out R&D, and adopting best practices to strengthen sustainability.

IFC’s active portfolio in the glass sector, including its own and mobilized investments, was valued at \$300 million in 12 projects across 10 countries in fiscal year 2020,¹⁷ with another \$100 million

committed in fiscal 2021. IFC’s portfolio includes projects involving float glass manufacturing and processing, and the manufacturing of glass for solar panels, insulation, and related composites, and of glass containers, pharmaceutical glass packaging, and glass fibers.

All IFC investments must adhere to the World Bank Group’s Environmental, Health, and Safety (EHS) Guidelines, which list performance levels and measures that IFC clients must follow. IFC supports clients to transition towards

more sustainable operations.

For the glass sector, key sustainability issues being addressed through IFC-funded initiatives include:

Efficient energy consumption

As glass manufacturing is an energy-intensive industry, efficient energy use is one of the core areas where IFC supports its clients, including maximizing cullet usage; introducing waste heat recovery techniques; controlling combustion; installing high-efficiency, low-energy compressors; and optimizing furnace sizes, among others.

In 2019, IFC provided financing to Middle East Glass Manufacturing Company, an Egyptian producer of glass containers, to rebuild its furnaces and streamline its cullet-processing operations to make them more energy-efficient. IFC also helped the company

develop an energy-efficiency plan to reduce its energy consumption. The plan identified the energy-efficiency measures to be adopted, the timeframe for implementation, and the anticipated energy savings.

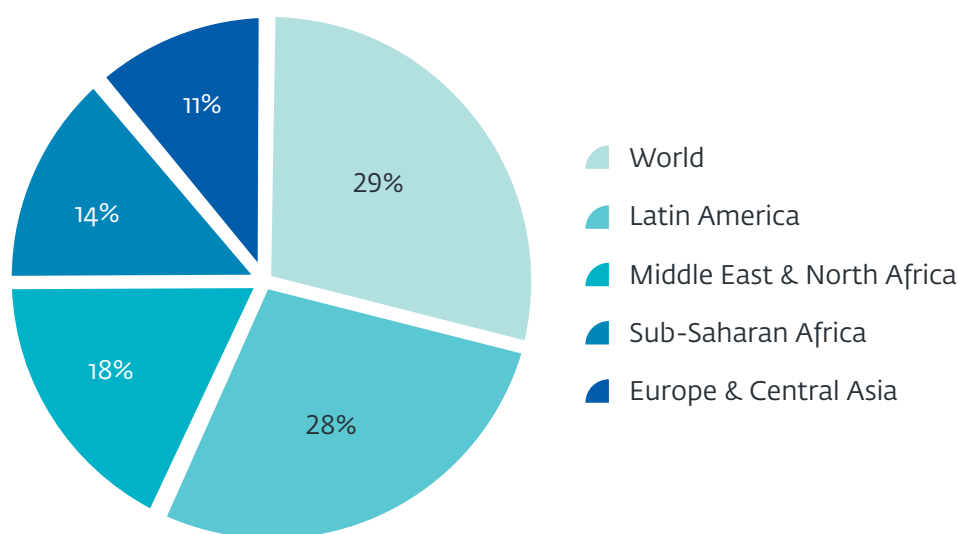
Emissions

Glass manufacturing unavoidably generates emissions, but some fuels burn cleaner than others, with natural gas and cleaner energy-based electricity creating less air pollution compared to fuels such as coal.

In Tanzania, IFC advanced credit to container glass producer Kioo Limited to upgrade its furnaces to reduce dust and NOx. Other measures implemented by IFC clients to abate emissions include the deployment of air-emissions control equipment, melting control panels, and modern furnace designs; the installation

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IFC Glass Industry Portfolio By Region, June 2020



Source: IFC 2020.

of electrical boosters over melting chambers and of catalytic ceramic filters; and the use of low NOx burners.

Glass manufacturing is also a significant emitter of greenhouse gases (GHG), particularly carbon dioxide, from the manufacturing process and fuel burn.

IFC works with its glass manufacturer clients to minimize the amount of greenhouse gas emitted into the atmosphere. Japan's NSG Group, a leader in architectural and automotive glass, upgraded its technology to optimize fuel utilization and recover heat in the production process, with the goal of minimizing such emissions. In 2019, IFC helped finance NSG's construction of a float glass production line in Argentina, including the installation of similar technology to curb emissions.

Recycling

Manufacturers that use recycled glass cullet not only save on energy consumption but also help to reduce the amount of waste in the environment and preserve valuable and rare natural resources used to produce glass. Glass recycling generates no processing by-products, and because the processing requires less heat, it also extends furnace life. Addis Ababa Bottle and Glass Share Company, a container glass manufacturer based in Ethiopia, utilizes

recycled glass in its production process (mainly of amber glass) with cullet typically comprising more than half of the batch composition, reducing the use of raw materials.

Product Innovation

IFC backs glass manufacturers' efforts to develop products that are more sustainable or that contribute towards sustainability in the industry or in the broader economy. For example, Turkey's Sisecam, one of Europe's largest glass producers, has focused on light-weighting its glass-packaging products, achieving a 14-percent reduction in greenhouse gas emissions on one of its bottle types simply by changing its design. The company also manufactures a unique coated glass called Solar Low-E coated glass, which is used in building. This glass reduces heat loss by 50 percent and helps save on energy costs compared to other flat glass products. Further, Sisecam has continually invested in R&D in recent years with the aim of ensuring its products create environmental and social benefits. As of 2020, it had more than 39 patented products that directly contribute to sustainability, such as its V-Block coating technology, which neutralizes viruses and bacteria on glass surfaces.

Conclusion

The demand for glass is projected to continue on an upward trajectory, along with growing pressure on the industry to further reduce energy use and greenhouse gas emissions. Over the last few decades, glass manufacturers have increased their sustainability through innovation, and they are expected to continue to do so through the rollout of new technologies and processes such as carbon capture. The sector also has a key role to play in boosting sustainability in other sectors, whether through lighter glass packaging or glass fiber used for wind turbine blades. All these efforts

will demand further investment in research and infrastructure, from waste-management facilities to collect and recycle end-of-life glass, to a guaranteed, steady supply of carbon-free electricity, to carbon capture transport networks and storage facilities. IFC's role will be to partner with forward-thinking and innovative players to improve their energy efficiency, lower their carbon footprint, and adopt circular economy strategies.

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