

**Towards an
International Year of Glass in
2022**



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International Year of Glass 2022 (IYOG2022) The global glass economy and its wider social consequences

For those working with glass there can be no greater undertaking this century than the celebrations planned for 2022. They will tell the story of glass in communication, aerospace, architecture, energy, healthcare, education, transport, agriculture and the arts. They will draw attention to the role glass can play in fulfilling the United Nations 2030 Sustainable Development Goals. Many glass-themed organizations and individuals have already enthusiastically embraced the project; numerous economic, social and educational activities across the globe are planned, benefiting humankind by advancing glass science, engineering and art. Financial support for these activities, advertising and direct administration is expected from the industry.

The worldwide glass industry

Glass adopts many guises and almost every area of our lives involves products with glass at their heart: from transport to homes and workplaces, from food production to health, leisure activities and communications, from museums to art galleries. Supporting the industry behind these artefacts are academic institutions, professional societies, national laboratories, museums, libraries, journals and glass-themed art studios. All have contributed to making glass one of the most transformative materials in history. This document summarizes the current place of glass in the global economy.

Industry sources list: 650 glass container¹ manufacturers in the world, operating on 1200 sites with an output of 95 million tonnes p.a.; 320 flat¹ glass manufacturers operating on 560 sites which produce around 106 million tonnes of flat glass p.a.; 230 manufacturers on over 400 sites melt nearly 8 million tonnes of glass p.a. for domestic glass/tableware¹. This is a massive global industry - 1200 companies, on 2160 sites, producing a staggering 209 million tonnes of glass annually; and these figures do not include glass fibre production, art, speciality glasses and secondary industries.

Market data experts estimate the global sector (not including fibres and special glasses) is worth \$189 billion (2016)² and is growing at a healthy 5.2% p.a. By product, the individual contributions are:

- Flat (and fabricated) glass: \$119 billion³
- Glass containers: \$53 billion⁴
- Domestic glass: \$11 billion⁵

¹ www.glassglobal.com

² In all the document billion= thousands of millions, this is: 10⁹

³ www.grandviewresearch.com/industry-analysis/global-flat-glass-market

⁴ <https://www.maximizemarketresearch.com/market-report/global-container-glass-market/19059/>

⁵ www.statista.com/statistics/935463/glass-tableware-market-value-worldwide/

- Smart glass: \$6 billion⁶

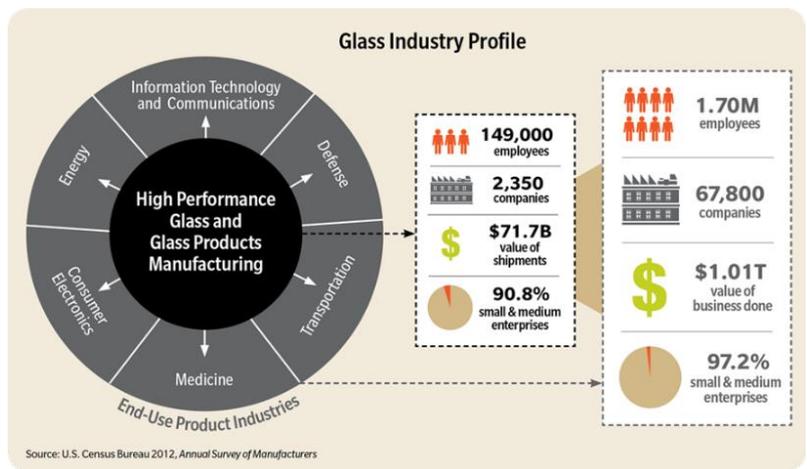
The figures below for output by weight for the EU include reinforcement fibres:

21,755,000 tonnes container glass	808,000 tonnes reinforcement fibre
10,643,000 tonnes flat glass	702,450 tonnes special glass
1,337,000 tonnes domestic glassware	158,720 tonnes other glass

Glass Alliance Europe (GAE) suggest that the EU, with a fifth of the global market, employs *directly* 200,000 people while downstream industries such as flat glass processing employ twice as many again⁷.

The US Glass Industry profile for high performance glass products below makes a similar point.

Each glass sector has its own manufacturing processes but similar melting techniques. Equipment is a major investment and the process requires sound environmental management but innovations can benefit other energy-using industries, smoothing the international transition to low carbon economies. In what follows we focus on 4 sectors involving commodity products. Speciality glasses, glass art and education are described with broader brush strokes.



Global production for flat glass

Flat glass is a mainstay of glass production and is dominated by one technology – Float (70 years old in 2022). Following the 2008 recession global demand for flat glass has steadily increased and is forecast to continue rising at 4.0% p.a. to 11 billion m² in 2021. Recovery of the construction sector in developed economies (particularly North America) and rapid expansion of new construction spending in emerging economies (Asia Pacific) are market drivers along with product innovation. Two-thirds of flat glass production is used in architecture, while much of the rest is for cars. Many of these applications involve secondary processing, for example cutting, grinding and polishing. Surface treatments can add considerable value by conferring characteristics such as self-cleaning, chemical resistance, light transmission control, thermal transmission control, electrical behaviour, increased mechanical strength and colour (essential for producing thermally efficient glazing⁸).

Plant construction is capital intensive, needs appropriate expertise and has traditionally been limited to a few major players but markets now influence the location of new facilities. The 2008 recession led to rationalisation and plant closures, less than 200 factories with 400 production lines remained, but then entry barriers fell and expansion began in emerging markets such as the BRIC countries (Brazil, Russia, India and China). In the last 15 years Russia has quadrupled its production plants to 8 while India has almost doubled to 7. Other developing markets are Asia,

⁶ <https://www.glassallianceeurope.eu/>

⁷ GAE-Annual Report 2019 - Statistical Data Global Glass Sector

⁸ BCC Research. AVM154A Glass and Glass Product Manufacturing: Global Markets to 2020
<https://www.bccresearch.com/market-research/advanced-materials/coated-flat-glass-technologies-and-global-markets.html>

Africa, the Middle East and South America. Algeria, Kyrgyzstan, Malaysia, Syria, Ukraine and Vietnam have all recently built furnaces.

Since 2015 China's flat glass production capacity has grown particularly rapidly mirroring its economic development; in 2019 capacity exceeded 60% of the global total causing a significant surplus. So, China's environmental protection and capacity replacement policies were tightened, restricting new production capacity. This required rapid industrial structural adjustment and diversification to higher-quality products.

Now, China's building and transportation industries are growing rapidly and fundamentally changing to energy-saving, safe and lightweight products. Green building is adding 1.6-2 billion m² annually to 60 billion m² existing floor area, 90% of which is in high-energy-consumption buildings that urgently need transformation. So the processing of energy-saving insulating glass, tempered vacuum glass, electrochromic glass, flameproof glass and other products will expand rapidly.

Following the Glass for Europe report⁹ glazing solutions offer the best energy balance between thermal insulation (U value) and the ability to capture or mitigate solar heat gains (g value). They foresee an energy saving potential in 2030 equivalent to a reduction of 30% in the energy consumption of buildings in Europe, 42% of the EU energy saving target.

China is now the largest car producer and consumer worldwide. In 2019 it manufactured almost 26 million vehicles, more than 40% of the global total. The operating mileage of high-speed railways is almost 35,000 km, 2/3 of the world's total. Such developments offer new opportunities for glass.

China is also the largest producer of Ultra Clear Photo Voltaic flat glass, with 3 million tons in 2016, over 70 % of global market share.

Global production/estimates⁴. The Compound Annual Growth Rate: 6% for tonnage, 7.2% for value.

Year	Million tonnes	Value (bn) US\$
2016	59.2	48.3
2020	84.0	90.2

Glass Packaging

The glass container industry is a second major force in the marketplace with global sales near US\$ 53 billion, split between beverages, cosmetics, food, pharmaceuticals and others. Beverage packaging is expected to remain dominant; wine bottles are two thirds of this total. Market expansion is expected to be faster than other areas of the economy, driven by exports and continued demand for packaging made of glass.⁶ So in 2018 glass packaging production in Europe increased by 2% in weight and 2.4% in unit terms. 21.5 million tonnes (78.1 billion units) were produced.

A vital attribute is the capacity for designing unique profiles identifying a brand. Other factors are transparency and inertness, ensuring long-term preservation of taste and visual impact. Weight is a disadvantage, but the industry is working hard on light-weighting. It is also investing in new products, increased energy efficiency and improvements in the environmental performance of glass products throughout their lifecycle. Future success will require companies

⁹ Potential impact of high-performance glazing on energy and CO₂ savings in Europe, TNO, 2019, <https://glassforeurope.com/glazing-saving-potential-2030-2050/>

to adopt 'smart technologies' that improve consumer experience and maintain product integrity across the supply chain.

Such trends are universal and Chinese colleagues report that glass is becoming the packaging material of choice for their government. The Chinese glass container manufacturing industry has experienced continuous growth in recent years. Aggregate operating revenue in glass-packaging container manufacturing industry was 61 billion yuan in 2019, an increase of 6% year on year. As a green product, the glass-container surely offers extensive development possibilities.

Of particular importance are the chemically resistant glass containers for pharmaceutical use (vials, ampoules, syringes, cartridges) obtained by converting neutral borosilicate glass tubes (300,000 tons in 2019 in rapid growth of 10-20 % per year). This is particularly important in world's quest in the delivery of a vaccine to fight the COVID-19 pandemic.

Glass is still a unique commodity in today's materials market. Used every day by billions of people, glass containers present countless advantages for both consumers and the environment. Being 100% recyclable, glass can be melted down and reformed an infinite number of times. The container glass industry is potentially a perfect example of a circular economy in action.

World market for smart glass

The first section covered Flat Glass made by the Float process. A distinct production route is needed for the thin glass sheets used in displays. A different glass is also used, one which can be ion exchange strengthened to confer greater mechanical strength. Over the past decade the display glass industry has grown explosively, driven by cost reduction and product improvement. While LCD panels still dominate (72% of the smartphone market), the industry recently has seen the introduction of display panels based on OLED technology.

The production costs for glass displays are high; the estimated annual market is \$ 6.4 billion. The market is supplied by 3 leading producers, US-based Corning, and Japanese firms Nippon Electric Glass and Asahi Glass, from manufacturing units distributed strategically around the globe. Corning has the dominant market share at 47%; Nippon and Asahi account for 22% and 24% respectively. Corning cover glass is used on more than 5 billion devices from 40 major brands worldwide. In 2018 their display glass division achieved sales of US\$ 3.2bn, 29% of their net sales¹⁰. More advanced, backplane technologies are taking a growing market share.

Up to 80% of smartphones are assembled in China. Consequently, the industry has been well supported and China has become the largest display industry development base in the world. Their output of smart phones, tablet computers, smart televisions and similar products is now more than 50% of the world's total. Currently, 21 production lines for Liquid Crystal Display panels are operating or under construction, a production capacity of 60% of the world's total; nearly \$ 100 billion has been invested and the annual demand for the larger TFT-LCD glass substrates is 380 million m².

As a vital component of display panels for such electronic products, ultra-thin touch sensor glass has a huge and growing market in China. Analysis suggests that 0.5-1.0 mm ultra-thin glass will have a market share reaching \$ 20.8 billion by 2024 with a compound annual growth rate of 12%.

According to "Consumer Electronics Market Share: Global Industry Analysis and Opportunity Assessment" released by the Future Market Insight (FMI) Company¹¹, the global consumer

¹⁰ Asian Glass Sept-Oct 2019 pp 34, 36, 38

¹¹ <https://www.futuremarketinsights.com/reports/consumer-electronics-market>

electronics market will develop at a compound annual growth rate of 15.4% over the next few years reaching \$ 2.98 trillion¹² by 2020. Bright spots include the move to larger TVs, the use of glass on the reverse side of smartphones, and the trend to foldable smartphones, all requiring more display glass per unit. Compared with plastic displays glass delivers a superior surface with improved durability, excellent scratch resistance and superior optical clarity.

Fibre glass

Another valuable product in construction is glass fibre, particularly for reinforced plastics and insulation; the global market currently is approaching \$ 10 bn p.a. A key application is pipework for transmission of water and other strategic liquids; storage tanks and baths for water are also important. Such applications are particularly significant in the Middle East where atmospheric conditions are extreme, and soils often saline; both cause rapid corrosion of alternative materials. China again is a dominant player with a 30% market share; the Middle East has key manufacturers and the USA market for these products is expanding too.

In 2019 China's total glass fibre output was 5.27 million tons, up 13% year on year, with a product yield of 4.5 million tons, a year-on-year increase of 3.5%. With increased globalization of glass fibre products, up to 20% of Chinese glass fibre and relevant products are being exported.

In the future glass fibre products are expected to displace steel, aluminium, wood, PVC and other traditional materials. Building, transportation and electronics industries in particular have enormous potential for using glass fibres. According to Trend Forecast and Opportunity Analysis of Global Glass Fibre Composite Market Report, the overall global glass fibre composite consumption will grow at 8.5% p.a., with the market size in 2022 expected to be up to 108 billion yuan. In the next 5 years five key fields - auto firmware, building decoration, safety protection, aerospace and liquid filtration - will take up 80% of glass fibre composites.

The glass fibre market has many other sectors based on novel glasses (chemical resistance, elastic moduli) and different fibre formats. A vital market is for wind turbine blades, a low carbon source of almost 20% of the world's electrical energy. A potential limiting factor may be health issues linked to materials handling and fibre ingestion but detailed studies have not uncovered the kind of problems linked to natural fibres such as asbestos.

Speciality Glasses and Functional Glasses

Earlier sections covered the four most economically important areas of glass production. There are many other applications and our lives would be much poorer without them. Consider for example: lenses for cameras, telescopes, binoculars and glasses; medical equipment for diagnosis and healing (toothpastes, syringes, even artificial eyes); tableware for cooking and drinking from, table decorations, glazing on pottery; jewellery; laboratory equipment and specialist manufacturing plant; and the optical fibres with in-fibre switching and amplification which underpin our communications industry. Secondary processing industries such as double and triple glazing manufacture, creation of fluorescent lights for advertising, add a further layer of economic activity.

Optical microscopes that contain special optical grade glass lenses have been fundamental for identifying and tracking many diseases including the current coronavirus infection. Many other uses of glass play a key role in meeting Sustainability Goals, including wind turbines and solar panels, and glass will play a prominent role in the oncoming 5G revolution.

Photovoltaic glass is the starting point for PV modules. After more than ten years of development, China has become the largest PV glass producing country in the world, making

¹² Trillion = millions of millions. This is: 10¹²

90% of the world's PV glass. Steady and orderly growth will be maintained during the next planning period giving an anticipated global installed power capacity of 520~540GW by 2025 and providing the cheapest renewable energy power source. The sales revenue of the global PV glass market is expected to be \$ 37.6 billion with the rise of dual glass crystalline silicon modules.

Smartphones, solar panels, fibre optic cables, lasers, and many other technologies that have changed the way we live would not exist without **high-performing functional glasses**. The unique properties of glass make it an ideal choice for a range of applications, and render glass manufacturing an essential part of the world economy. Innovative breakthroughs in functional glasses can enable new solutions to some of society's grand challenges. For example, R&D of functional glass promises to increase energy efficiency and environmental sustainability, improve health and welfare, enhance national security and workforce safety, enrich information sharing, and advance mobility. With increased investment over the next 10 years, further innovations in functional glass manufacturing could deliver new solutions to these critical challenges and further transform our way of life.¹³

Art Glass

The art glass sector uses fewer expensive mechanical aids and supplies a different sector of the market. The Island of Murano, Italy is one of the go-to places for glass art and its economy is heavily reliant on artefacts whose price can range from \$10 to many thousand \$. Rich and developing countries alike have small businesses making and selling glass souvenirs of local tourist attractions *or* producing beautiful products made from glass such as earrings, necklaces, beads, or cuff links as well as glass sculptures for churches, gardens and public places. Sea glasses, unlike plastic waste, are prized by beachcombers; created by the incessant tumbling action of waves on discarded glass fragments, their rounded shapes with translucent delicate colours are much appreciated. The Studio Glass movement whose 60th Anniversary we intend to celebrate is but one more vibrant area within this picture.

Art glass underpins a lively industry for collectors, funding auction houses and at the heart of many museum displays, including numerous collections of international and historical importance. A recent study identified over 200 museums across the globe that either emphasize the history of glass or the current state of glass art and engineering. Programs involving artistic/scientific glass blowing, stained glass artistry, or jewellery making are highly popular with society at large but even more so with educators at the elementary, secondary and university levels. While quantifying the worldwide annual economic impact of these efforts is difficult, it is substantial in those communities where they are located and adds to the quality of life for all involved. The Corning Glass Museum also houses the Rakow Research Library, a major international research resource for locals and visitors alike. A similar collection is held in Venice.

Education and Professional Societies

Glass making is highly skilled and numerous establishments offer courses a) for glass artists, b) the technicians to run factories and c) the research workers who use the special properties of different glasses to create new products for the many challenges civilisation faces. While specific data summarizing their annual economic impact are not available, it is clear a) they are located throughout the world and b) they are vital for advancing the fields of glass science, engineering and art. These institutions promote educational opportunities, conduct basic research, organize well attended conferences, and publish advances in both glass science and engineering in highly respected journals or as highly acclaimed textbooks.

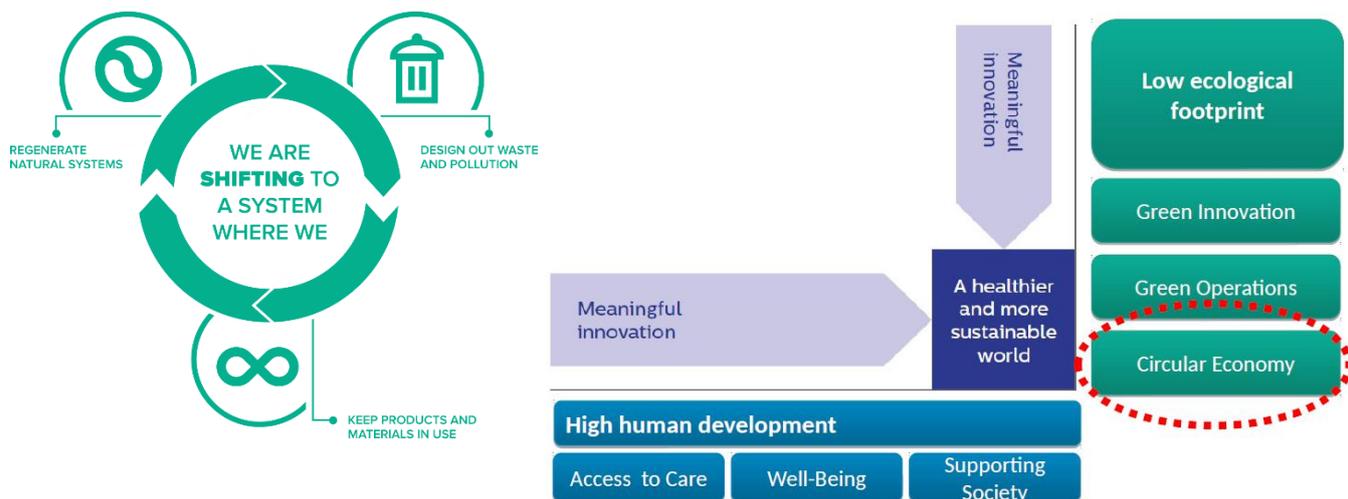
¹³Driving functional glass manufacturing innovation: a technology roadmap to 2025.
<https://ceramics.org/wp-content/uploads/2019/05/FGMIC-roadmap.pdf>

Many of these activities are nurtured, supported, and chronicled by the International Commission on Glass – now in its 87th year of operation - which has assumed the major responsibility for planning, pursuing, advocating, and overseeing the activities for the proposed International Year of Glass.

Glass in a circular economy

In 1684 Thomas Savery invented the steam engine, so kick-starting the industrial revolution by transforming our ability to make things. Raw materials and energy were seemingly infinite, and labour was readily available. For the first time in history, goods were mass-produced. However, this system is no longer working: for business, the population or the environment. We extract resources from the ground to make products, which we use, and, when we no longer want them, throw them away. Take-make-waste.

A circular economy is a way to design, make, and use things within environmental boundaries. Its principles are to design out waste and pollution, keeping products and materials in use. A circular economy ensures decoupling of development and footprint. Glass is a key material for achieving the goal of **economic and ecological value creation**. Many aspects of this approach are a significant part of the worldwide glass economy and offer gainful employment opportunities.



In Europe, the implementation of a truly circular economy could reduce carbon emissions by around 70%. The glass industry has for millennia used recycled glass, i.e. cullet, to conserve materials, lower melting temperatures so saving energy and now as an effective way to reduce emissions. In the EU 74% of container glass, the largest glass sector in tonnage, is recycled, saving around 9 million tonnes of CO₂ every year.

A circular economy must be a building block to a future decarbonized world and the yet untapped potential for further recycling should be addressed. End-of-life architectural glass remains a largely unexploited resource and requires action by public authorities. In the EU the proper recycling of all building glass waste could avoid 925,000 tonnes of landfill saving around 1.23 million tonnes of primary raw materials annually. Designs and specifications for new glass façades should be regulated to maximise the potential for recycling while off-cuts from

secondary processing in the insulating glass and automotive industries are another valuable resource¹⁴.

Turning waste flat glass into cullet is subject to waste management legislation. Beyond the investment in infrastructure, national/regional/local regulatory measures could be considered to close the loop by promoting pre-demolition and banning recyclable waste in landfill.

Education is essential to achieve a circular economy. Curricula for higher education are being implemented and adapted to High School. Educational resources include videos, graphics and articles supporting lesson plans; an IYOG is the ideal way to promote and disseminate them.

From greener transport to efficient architectural glazing, from the installation of PV panels to the use of glass containers that respect the 3R rule, glass is essential to reduce the use of natural resources, lower CO₂ emissions and pollution and enhance the life of citizens.

Value of an IYOG

The International Year of Glass will be a major force in promoting the building of a truly circular economy in glass, promoting sustainable development across the world. It will promote widespread documentation and dissemination of best practices for example through international conferences and meetings. It will encourage networking and collaboration between industry and academia, essential for improving understanding of processes and products and for discovering the best routes to a circular economy and sustainability. In-depth discussion can lead to melting technologies that minimise or eliminate CO₂ and NO_x generation; reduced environmental and social impact of the glass industry; and maximise efficiency and quality. Regulations and standards, tighter inspection procedures and new products with enhanced characteristics are further areas ripe for global cooperation. This is a win-win process for glass, since reductions in the raw material and energy inputs define the final price of a product. So, our ambitions are to:

- Stimulate discussion on Green Innovation to lower the carbon footprint of glass products,
- Develop a glass industry and products that do not impact negatively on the environment,
- Promote the design of affordable Green Buildings for different environments,
- Promote glass containers which follow the 3R rules for recycling,
- Promote education throughout the world as an essential tool to build sustainability,
- Ensure access for all to reliable communications and knowledge bases,
- Promote the opportunities glass offers to improve dental and medical health care for all,
- Extend the benefits of the Internet and 5G to developing nations, encouraging sustainable growth,
- Teach the next generation to understand the past and imagine the opportunities the future gives.

Summary

We are in the Age of Glass, a material which has affected humankind for centuries and continues to be a major component in our economic and social fabric. It lies at the unseen heart of the everyday, enriching our lives and the world's economy. Celebrating an International Year of Glass can only strengthen and advance its contribution to commerce, to the fulfilment of the United Nations 2030 Sustainable Development Goals, and to making glass identifiable as a catalyst for enhancing our quality of life without destroying our planet.

¹⁴ Building glass into the circular economy. <https://www.ukgbc.org/ukgbc-work/building-glass-into-a-circular-economy/>