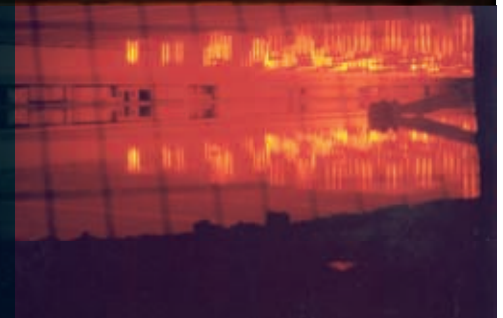




NSG Group

and the Flat Glass
Industry 2011



NSG Group and the Flat Glass Industry 2011

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Introductory Note and Definitions

The objective of this publication is to provide background information on the world's flat glass industry and, as an industry leader, the position within it of the NSG Group.

In June 2006, Nippon Sheet Glass Co., Ltd acquired Pilkington plc through NSG UK Enterprises Limited; a wholly-owned subsidiary. All of the operations of the former Pilkington plc are now fully integrated into the NSG Group.

Where the operations of the whole Group are referred to collectively, the terms 'NSG Group' or 'the Group' are used. The Group's flat glass businesses comprise Building Products businesses in Europe, Japan, North America, South America, China and South East Asia, which are managed on a regional basis, and the Group's Automotive business, which is managed globally.

It should be borne in mind that the flat glass businesses of the NSG Group account for just under 90 percent of the NSG Group's business by sales and that the Group also has a third business line, Specialty Glass, accounting for around 11 percent of Group sales, which is not covered by this publication.

Consequently, any figures referring to 'Pilkington' or 'NSG Group flat glass' sales and operating income are lower than those for the NSG Group as a whole. The strategic direction of the NSG Group itself is covered in Part Three of this publication.

The operating currency of the NSG Group is the Japanese yen. However, for ease of reference, some figures are expressed in euro and any figures relating to financial performance are therefore approximate. This publication should be read in conjunction with the NSG Group Annual Report 2011, covering the fiscal year ended 31 March 2011.

This document is also available to download in pdf format from the NSG Group website at www.nsg.com.

The Pilkington brand mark



An important element of the acquisition of Pilkington plc by NSG in 2006 was the retention of the Pilkington brand in the NSG Group's Building Products and Automotive businesses.

The Pilkington name promotes many of the Group's world-leading products and is used in some of the names of Group subsidiary companies.

Executive summary

The flat glass industry and global market structure

- The global market for flat glass in 2010 was approximately 56 million metric tonnes, representing a value at the primary manufacture level of around euro 23 billion and euro 53 billion at the level of secondary processing.
- This market has historically been growing in volume terms at 4 percent to 5 percent a year.
- Of total global market demand in 2010, it is estimated that 33 million tonnes was for high quality float glass, 1 million tonnes for sheet glass and 2 million tonnes for rolled glass. The remaining 20 million tonnes reflects demand for lower quality float, produced mainly in China.
- In 2010, 40 percent of float glass went into new buildings and the same proportion into refurbishment for buildings.
- Approximately 3.7 million tonnes of the flat glass produced globally for calendar year 2010 was automotive glass.
- Globally, around 80 percent of Automotive glass goes into OE supplied to vehicle manufacturers for new vehicles and 20 percent in to the AGR aftermarket.
- Approximately 1.5 million tonnes of flat glass in calendar year 2010 was consumed in Technical Applications. The most notable of these is solar energy.
- Considering high quality float alone, the industry is relatively consolidated, with four companies accounting for a majority of global capacity.
- In terms of the capacity, the world's top four companies are led by the AGC and Saint-Gobain. NSG comes in at number three, followed by Guardian Industries.
- NSG Group's share of global, high quality float capacity is approximately 13 percent.
- Three glass groups, NSG Group, AGC and Saint-Gobain together with its strategic partner Central Glass, supplied around two-thirds of the glass used in the automotive industry during calendar year 2010, according to our estimates.
- Following the acquisition of Pilkington by NSG, just less than 90 percent of the combined entity is concerned with flat glass, significantly higher than the nearest competitor, AGC at less than 50 percent.
- Europe, China and North America, together account for over 75 percent of high quality float demand.
- Automotive light vehicle production in 2010 was 72 million, of which 35 percent was in the two main markets of Western Europe and North America. Build in Japan contributed a further 12 percent.
- These three regions account for 47 percent of global light vehicle production and are also the domiciles of most of the world's vehicle manufacturers and are the centers for new vehicle development.

Glass - a growth industry

- Over the long term, demand for float glass is growing at almost 5 percent per annum. This growth is fuelled by the demand for building glass and automotive glass, which in turn is driven by economic growth.
- Over the last 20 years, float demand growth has outpaced real GDP growth. Over the past 10 years, float demand has exceeded GDP growth by around three percentage points.
- The world flat glass market is expected to recover to almost 60 million tonnes in 2011, including 2 million tonnes of rolled glass, from the recession-hit 2009 level of 52 million tonnes.
- The pace of capacity addition outside China has moderated recently, with eleven new lines on stream in 2010 but only three expected in 2011.
- Architects are increasingly seeking to bring natural environmental factors into the interior of buildings by maximizing natural daylight. This has been achieved through the use of larger glazed areas in façades and roofs, and through entirely glazed façades, where the glass is a structural component of the building.

- Over the past 25 years, in developed regions such as Europe, Japan and North America, the growing need for energy efficiency in buildings has transformed the markets for energy-saving glass and this is now being echoed in developing regions.
- In Automotive, the basic driver of demand for suppliers to the OE industry is vehicle build. Historically the global industry has exhibited steady growth; an average of around 2.5 percent per annum over the last 13 years.
- However, the downturn which hit the industry in 2008 and 2009 on the back of the global economic crisis was unprecedented both in terms of its spread and its scale. Its severity reduced the historical growth rate closer to 1%. The recovery now underway together with natural growth in developing markets is expected to restore the long-term average industry growth to 3% by 2015.

NSG Group - a glass industry leader

- The NSG Group, which operates under the Pilkington brand in Building Products and Automotive, is one of the world's largest manufacturers of glass and glazing products for the building and automotive markets.
- The Group has manufacturing operations in 29 countries on four continents and sales in around 130 countries.
- In the fiscal year ended 31 March 2011, the NSG Group reported sales of JPY 577,212 million (approximately euro 5 billion).
- Of the Group's consolidated sales, 41 percent were generated in Europe, 29 percent in Japan, 14 percent in North America and 16 percent in the rest of the world.
- Building Products and Automotive now account for around 90 percent of NSG Group sales.

Geographic positioning; Building Products and Automotive

- Building Products has manufacturing operations in 21 countries. Its largest operation is in Europe, with major interests in Japan, North and South America, China and South East Asia.
- Pilkington Automotive is one of the world's largest suppliers of automotive glazing products. It operates in three main sectors; supplying original equipment, aftermarket replacement glass and products for specialized transport.
- Its footprint, including fabrication plants, OE satellite facilities and its AGR distribution network encompasses Europe, Japan, North and South America, China, South East Asia and India.
- The NSG Group is one of only four companies in the flat glass industry that can claim to be true global players, the other three being AGC, Saint-Gobain and Guardian.
- The integration of the Pilkington and NSG business platforms has historically helped mitigate the effects of market cycles in the area of architectural glass and has given the Group a superior presence in developing markets such as South America, China, South East Asia and Russia.
- The NSG Group's manufacturing base includes float glass lines operating in Europe, Japan, the Americas, Southeast Asia and China, with Automotive operations covering all major markets worldwide.
- The Group owns, or has interests in, 49 float lines, giving full coverage of the global market and providing the Group with advantages in terms of strategy, efficiency and effectiveness.

Technical leadership

- The Pilkington brand is closely identified with technical excellence, having been associated, over the past fifty years, with most major advances in glass technology, including the invention of the Float Process.
- The NSG Group is a global leader in manufacturing excellence and innovation, notably in the areas of glass melting, glass forming by the float process, online coating and complex shaping technology, especially for automotive windshields and backlights.

Strategic Direction

- In January 2009, the Company announced restructuring initiatives designed to address the economic downturn and to improve profitability going forward. These built on action already taken in response to sudden and rapid changes in the global economic environment.
- Announced in November 2010, the Group's Strategic Management Plan covers the three-year period ending 31 March, 2014. The Plan focuses on two main areas for growth:
- Expansion into emerging economies. The Group's main targets are South America, Eastern Europe and China.
- Meeting increasing global demand for environmentally-friendly glass products, which help address climate change issues. These include low-energy-saving and solar control glass and products for the growing solar energy sector.

Sustainability

- Glass has a unique contribution to make in promoting sustainability, reducing greenhouse gas emissions and mitigating the effects of climate change.
- The 'energy balance' between manufacture of high-performance glazing products and their use means that the energy used and CO₂ emitted in manufacture are quickly paid back through the lifetime of the products. The energy involved in glass-making should therefore be seen as an investment in future energy saving.
- Glass has a key role in attempts to find cheaper and more efficient ways of generating power from the sun. The Group's products support the three leading solar energy technologies; thin film and crystalline solar modules and concentrated solar power applications.
- The NSG Group is fully committed to sustainability. Its policies underline the unique contribution its products can make to addressing climate change and the challenges the Group faces in improving its own energy usage and resource management. The Group's product range and R&D efforts are geared to addressing the challenges of a low-carbon world.

1. Global flat glass industry and market structure

1.1. Total world market for flat glass

The global market for flat glass^A in 2010 was approximately 56 million metric tonnes (~5.5 billion sq m)^B. At current price levels this represents a value at the level of primary manufacture of around euro 23 billion. This market has been growing in volume terms at 4 percent to 5 percent a year and recovered well in 2010, but short-term uncertainties remain in the light of global economic conditions.

Of total global market demand in 2010, it is estimated that 33 million tonnes was for high quality float glass. Approximately 1 million tonnes constituted demand for sheet glass and 2 million tonnes was for rolled glass. The remaining 20 million tonnes constituted demand for lower quality float, produced mainly in China.

Generally, flat glass demand growth is a function of economic activity levels. Long-term growth potential for flat glass can be estimated with reference to growth of gross domestic product, or GDP. However, demand

for glass may deviate from GDP for a variety of reasons, for example due to government programs that subsidize certain glass products.

Following manufacture, a portion of the high quality float and rolled glass produced globally is further processed by laminating, toughening, coating and silvering, for use typically in insulating glass units or automotive glazing. When these processed products are also considered, the global market for flat glass had a value of approximately euro 53 billion for 2010.

The global flat glass market is worth around euro 23bn at the primary level and euro 53bn at the level of secondary processing.

A - Glass manufactured in flat sheets (float, sheet and rolled), which may be further processed. Excludes bottles, containers, fiberglass, rods, and tubes

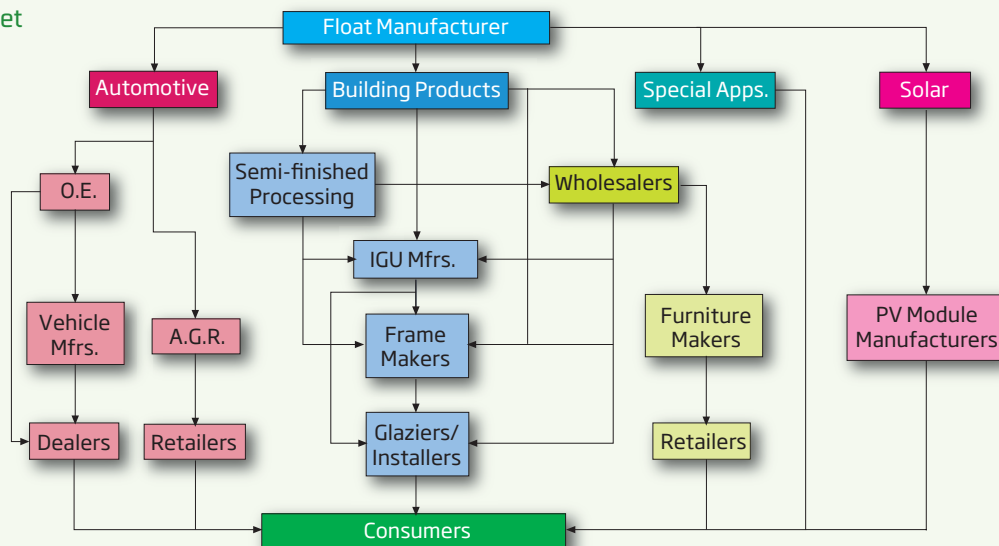
B - On average 1 tonne is approximately 125 sq m.

1.2. Routes to market

The chart below illustrates the main routes to market in the glass industry. In terms of volume of glass consumed, Building Products is by far the largest sector (~51 million tonnes) with ~3.7 million tonnes going to Automotive. The Technical Applications segment is very small in volume terms, but significant growth is being driven by the use of glass in Solar Energy generation.

In Building Products, glass can undergo two or more levels of processing before being installed in windows or used as a component in furniture or white goods. Within Automotive, glass is used in original equipment for vehicle manufacturers and in the manufacture of replacement parts for the aftermarket.

Routes to market



In terms of volume of glass consumed, building products is by far the largest sector of the global market for flat glass, accounting for approximately 51 million tonnes in calendar year 2010. Glass is an integral building material for most construction projects. Also, we estimate refurbishment for buildings accounted for approximately 40 percent of flat glass consumption worldwide for calendar year 2010. Building products include float and rolled glass and other processed building glass products (including toughened, coated and silvered glass) for exterior and interior applications.

Approximately 3.7 million tonnes of the flat glass produced globally for calendar year 2010 was automotive glass, another key sector of the glass industry. Automotive glass products are generally categorized as either OE supplied to vehicle manufacturers for new vehicles or as AGR products, which are supplied to the aftermarket for retrofit purposes, usually following damage. Globally, OE glass demand is estimated to be around four times that of the replacement market, though the proportion varies from region to region.

Global Building Products Flat Glass Market by sector

Sector	Volume	
New Build	1,900 million m ²	40%
Refurbishment	1,900 million m ²	40%
Interior	900 million m ²	20%
TOTAL	4,700 million m ²	100%

Most glass is used in building, with a further significant portion used in automotive applications and a small but growing amount in other specialist areas.

1.3. Industry economics

A float plant is highly capital-intensive, typically costing around euro 70 - 200 million, according to size, location, quality and product complexity. Once operational, it is designed to operate continuously, 365 days per year, throughout its campaign life of between 10 and 15 years. Float lines are normally capable of several campaigns following major rebuild/upgrade programs.

The economics of the continuous-flow float operation require a high capacity utilization rate before a plant becomes profitable. Once that rate (around the 75 percent range) is passed, the inherent operational leverage of the asset base increases profitability rapidly. Product diversity, in terms of both glass composition and thickness, can reduce nominal

Global Automotive Glass Products Market by Sector

Sector	Volume	
Original Equipment (OE)	315 million m ²	80%
Aftermarket (AGR)	80 million m ²	20%
Total	395 million m ²	100%

Global Technical Applications Flat Glass Market by sector

Sector	Volume	
Solar Energy	80 million m ²	10%
Other	350 million m ²	90%
TOTAL	425 million m ²	100%

Estimates CY 2010

Within the OE glazing market, by far the largest segment is light vehicles, normally defined as those vehicles up to three and a half tons in weight. Light vehicles include all cars, light trucks and the various cross-over vehicle styles such as sport utility vehicles, and accounted for approximately 96 percent of global automobile production in calendar year 2010.

Approximately 1.5 million tonnes of flat glass in calendar year 2010 was consumed in technical applications. The most notable of these is solar energy. There are three main types of solar energy generation: crystalline silicon, thin film and solar concentrators. Each of these has demonstrated strong growth in the past several years, and although the global recession has reduced growth rates in the last year, the market is expected to exhibit steady growth in the short term. In the medium-to-long term, growth rates may increase again, as the cost of solar energy generation begins to approach the lower costs of conventional energy.

output, as transition product is lost when float production changes from one specification to the next. In the most complex float composition changes, this can amount to as much as seven days' lost production. However, such changeover losses can be minimized through coordinated production scheduling of regional float assets.

The float process is not labor-intensive. Energy and raw material costs are each as significant as factory labor in the overall delivered cost. Glass is relatively heavy and comparatively cheap, making distribution costs significant; they typically represent around 15 percent of total costs.

In most cases, transport costs make it uneconomic for float glass to travel long distances by land. Typically, 200 km would be seen as the norm, and 600 km as

the economic limit, for most products, although this varies between markets. It is possible for float glass to be economically transported longer distances by sea provided additional road transportation is not required at both ends. This tends to favor float lines with local port access, unless a local market is available for the line's output.

A float plant is designed to operate continuously, 365 days per year, throughout its campaign life, which is typically between 10 and 15 years.

Investment costs in Automotive, though somewhat lower than in Float, are nevertheless significant. By way of example, investment in a typical European automotive glazing plant with capacity to fully glaze one million cars per year could cost between euro 40 million and euro 60 million, depending upon the technology employed, the degree of automation and its location. Annual revenue from such an investment would be approximately euro 50 million.

Typically, automotive glass plants are at their most efficient with long production runs. However, bespoke glazings for each aperture of every model tend to

mitigate against this, particularly where model variants are relatively low-volume in automotive industry terms. Where production runs are shorter, requiring frequent tooling changes, different automotive shaping technologies will be employed. Therefore, an automotive glass manufacturer requires an appropriate demand and asset mix for optimal operation. As with float, the scale of the major automotive glass processors requires them to leverage their regional facilities in this way.

Overall, automotive glazing production tends to be more labor intensive than float manufacturing, and growth in value-added activities is increasing this requirement.

Automotive glass can and does travel significant distances and, while vehicle manufacturers (VMs) are increasingly seeking local service from their suppliers, in the case of glazings this usually takes the form of a small satellite operation rather than a major processing plant.

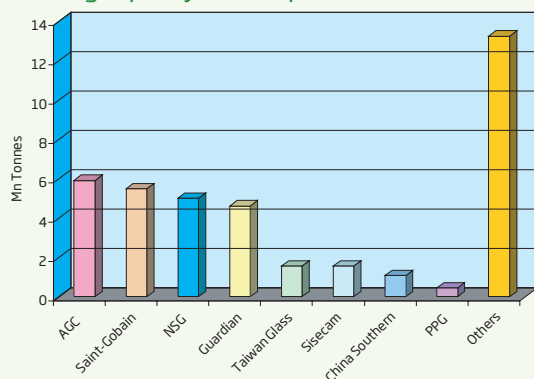
Investment in a European automotive glazing plant with capacity to fully glaze one million cars per year could be expected to cost between euro 42 million and euro 63 million.

1.4. Global players and market shares

Considering high quality float alone, the industry is relatively consolidated, with four companies accounting for a majority of global capacity. The NSG Group's share accounts for approximately 13 percent overall. In addition, there are three companies which together supplied around three-quarters of the glass used in the automotive industry during calendar year 2010, according to our estimates.

Of the four companies manufacturing most of the world's glass, NSG Group and AGC are based in Japan, Saint-Gobain is based in France and Guardian Industries Corp, or Guardian, is based in the United States.

World high quality float capacities 2010



The NSG Group has >13 percent of global high-quality glass capacity.

Capacity share by company

Company	Country ^a	Percentage of World Capacity
AGC	Japan	15
Saint-Gobain	France	14
NSG Group	Japan	13^b
Guardian	United States	12
Others		46

a. The country in which the parent company is domiciled.

b. Including affiliates.

Portfolio comparison of the major players

In terms of the capacity, the world's top four companies are led by the AGC and Saint-Gobain. NSG comes in at number three, followed by Guardian Industries.

The NSG Group is the most focused glass company, combined with wide geographic reach.

The NSG Group and AGC have the greatest geographic reach of these flat glass companies followed by Saint-Gobain. Guardian's global coverage in float glass is high, but its limited automotive footprint leaves it in fourth place overall, followed by Taiwan Glass and Sisecam.

Following the acquisition of Pilkington by NSG, just less than 90 percent of the combined entity is concerned with Flat Glass, significantly higher than the nearest rival, AGC at less than 50 percent. Saint-Gobain's, flat glass focus is the lowest of all five majors, at about 12 percent.

1.5. World float/sheet glass markets

In the following analyses the world is segmented into eight regions as follows:



In this analysis rolled glass is excluded and, unless otherwise stated, market figures are calendar year 2010, based on company estimates.

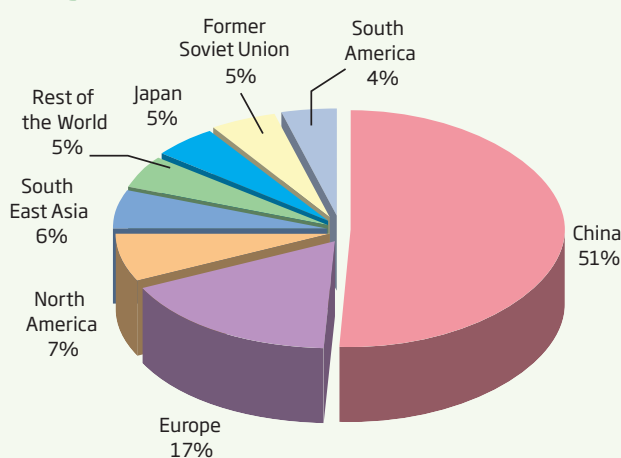
General overview

The global market for float/sheet glass (excluding rolled) in 2010 was approximately 54 million tonnes. This is dominated by Europe, China and North America, which together account for over 75 percent of demand.

The significance of China as a market for glass has been increasing rapidly since the early 1990s as the country has become more open to foreign investment and the economy has expanded. In the early 1990s

China accounted for about one fifth of world glass demand, but now accounts for just over 50 percent.

Regional float & sheet demand 2011



Europe, China and North America together account for over 70 percent of global demand for glass.

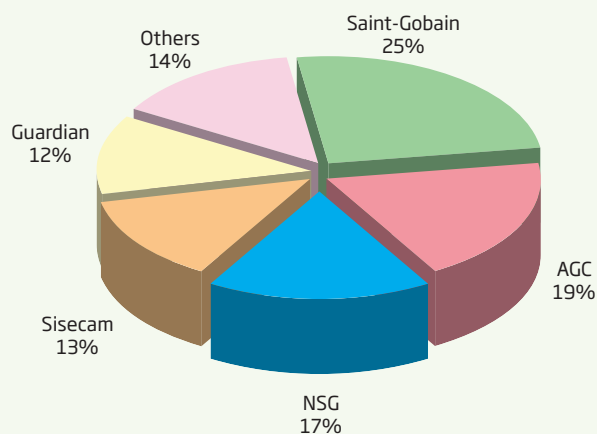
Europe

In this definition, Europe includes Turkey, but not Russia, Ukraine and Belarus.

Europe, with a market size of nearly 9 million tonnes in 2010, is supplied by eight main manufacturers of float glass: Saint-Gobain, NSG Group, AGC, Guardian, Sisecam, Euroglas, Sangalli and Interpane. Europe is a mature market with the highest proportion, among the eight regions, of value-added products, such as coated and laminated glass, which are largely produced by float glass manufacturers. Per capita glass consumption was approximately 14 kg in 2010.

Downstream processing, into insulation glazing units for example, is generally done by smaller independent players. Saint-Gobain, NSG Group and AGC participate at this level of the market, but with lower market presence than in primary manufacturing.

European 2010 float/sheet capacity by company



Total installed capacity was approximately 12.3 million tonnes in 2010, of which only about 50,000 tonnes was sheet glass.

Europe is the most mature glass market and has the highest proportion of value-added products.

Europe float lines

As of August 2011, new float investments by Siseecam in Bulgaria and Sangalli in Italy had come on stream, adding to the region's capacity.

Government subsidies play an important role in encouraging solar generation, especially in Europe, with feed-in tariffs in countries such as Germany, Spain, Italy and Greece. Public spending restraints have recently put these incentives under pressure.



- NSG (11)
- △ Guardian (8)
- Saint-Gobain (17)
- ★ AGC (13)
- ☾ Siseecam (8)
- ✕ Sangalli (2)
- ◆ NSG/Saint-Gobain (1)
- Euroglas (4)
- ★ AGC/Scheuten (1)
- ⊕ Interpane (1)
- ⊗ Interpane/Scheuten (1)
- ◆ GES (1)
- ▽ Okan-Cam (1)

Japan

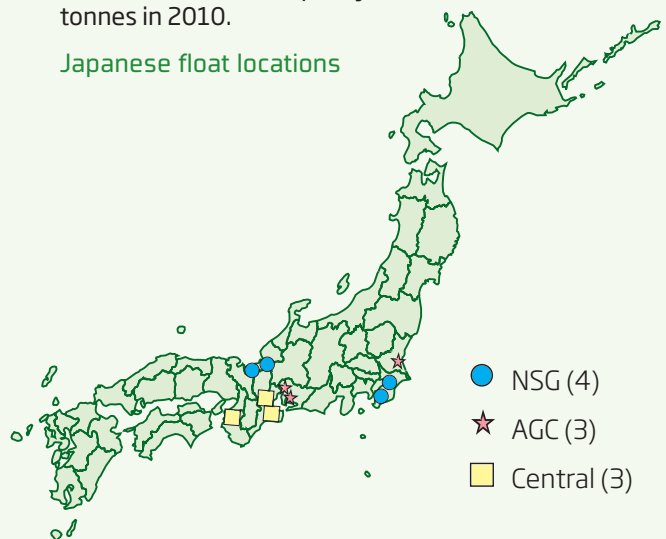
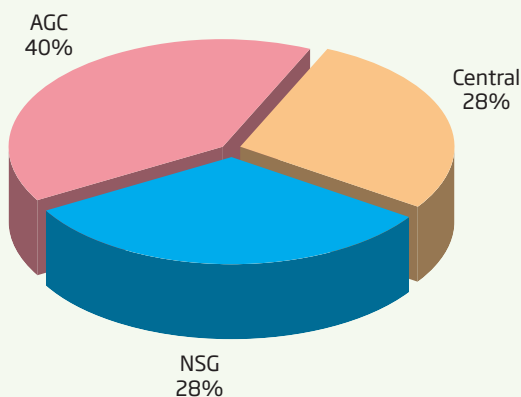
There are three major float glass manufacturers serving Japan: NSG Group, AGC and Central Glass.

The overall market size for float glass was 1 million tonnes, and per capita glass consumption was around 8kg, in each case for 2010.

Total installed float capacity was over 1.2 million tonnes in 2010.

Japanese float locations

Japanese 2010 float capacity by company



- NSG (4)
- ★ AGC (3)
- Central (3)

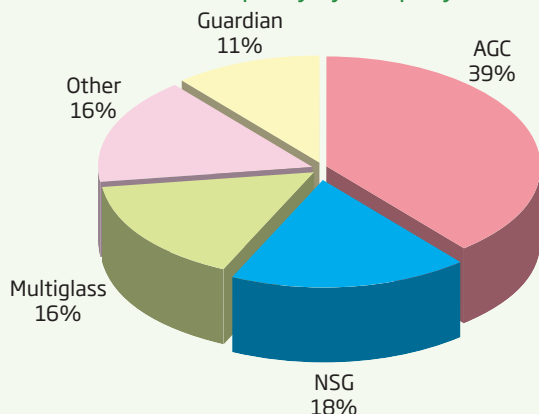
Three float glass manufacturers in Japan, with an overall float market size of one million tonnes.

ASEAN

The ASEAN market described below refers to Brunei, Indonesia, Cambodia, Laos, Myanmar, Malaysia, Philippines, Singapore, Thailand and Vietnam.

The ASEAN market size was just over 2.3 million tonnes in 2010. Over 20 float lines were operating in the region, which were owned primarily by four main glass manufacturers and several local concerns. Per capita consumption during 2010 was around 4 kg.

ASEAN 2010 float capacity by company

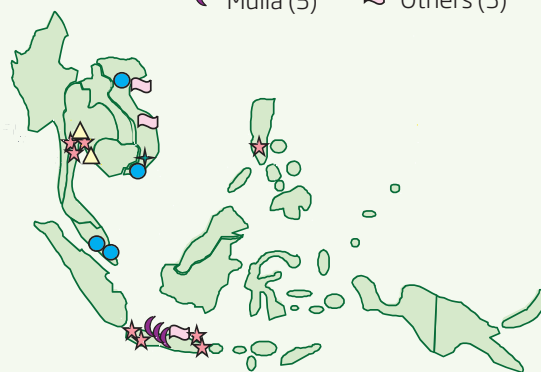


Total installed flat glass capacity was over 2.5 million tonnes in 2010, of which approximately 30,000 tonnes was sheet glass.

21 float lines are installed in the ASEAN region.

ASEAN float lines

- NSG (4)
- ★ AGC (8)
- ◐ Mulia (3)
- △ Guardian (2)
- ✦ Viglacera (1)
- ◑ Others (3)

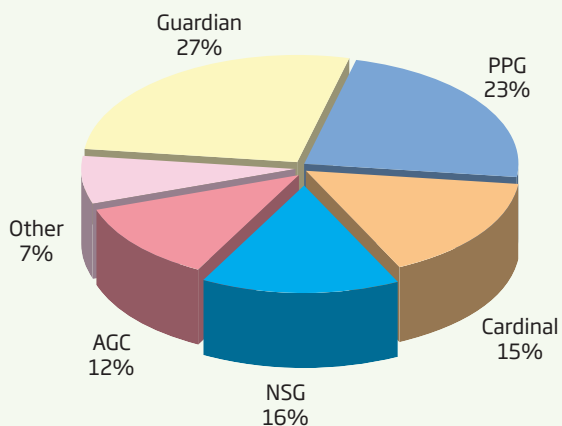


US/Canada

US/Canada is a mature glass market with annual demand of around three million tonnes, equating to consumption of around 8.5 kg per capita in calendar year 2010.

The industry at the primary level has seven significant players. Pittsburgh Glass Works is the latest to join the market after it acquired two of PPG's float lines.

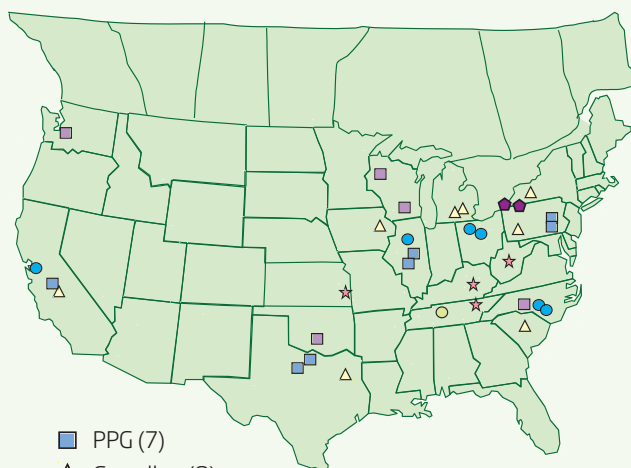
US/Canada 2010 float capacity by company



At a primary level, the flat glass industry in US/Canada has seven players.

US/Canada float lines

- PPG (7)
- △ Guardian (8)
- NSG (6)
- Cardinal (5)
- ★ AGC (4)
- Zeledyne (1)
- ◆ Pittsburgh Glass Works (2)



Total installed float capacity was approximately 4.8 million tonnes of high quality float glass in 2010.

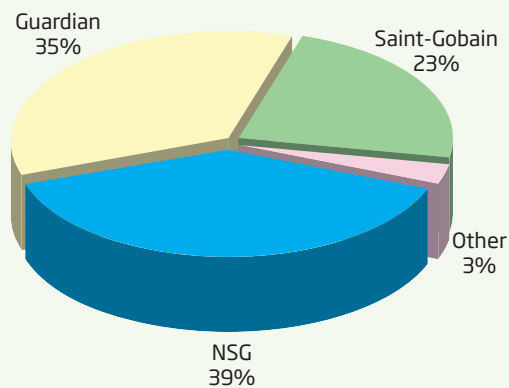
South America

South America had a market size approaching 2.4 million tonnes in calendar year 2010, and an annual per capita glass consumption of around 6 kg.

There are three manufacturers of high quality float glass: NSG Group, Saint-Gobain and Guardian.

Six of the eight float lines in this region are joint venture operations between NSG Group and Saint-Gobain, of which four are managed by NSG Group.

South American float/sheet glass capacity by company



Total capacity was over 1.5 million tonnes for calendar year 2010, of which less than 40,000 tonnes was sheet glass.

South American float lines



In South America, there are three manufacturers of high quality float glass: the NSG Group, Saint-Gobain and Guardian.

China

China is the largest consumer of glass in the world, accounting for 51 percent of global demand in 2010.

China is also the largest producer of glass and glass products, producing over 50 percent of the global output of flat glass in 2010. It has the greatest number of glass producing enterprises, and has the largest number of float glass production lines in the world.

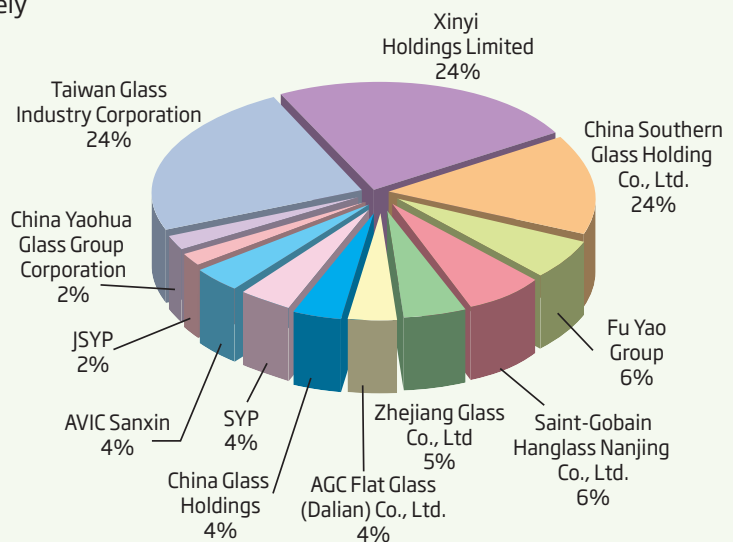
As of 2010, approximately 220 float lines were believed to be installed, although only approximately 50 of these float lines are equipped to produce western quality float.

Nevertheless, the quality and output of Chinese float glass is increasing. In terms of consumption and output, the market has grown at more than 10 percent per annum during the period from 2000 to 2010. Global economic conditions slowed both demand and capacity growth in 2008 and 2009 but the growth has recovered well, with capacity increasing nearly 10 percent and demand 11 percent in 2010.

Most Chinese manufacturers are small and medium-sized enterprises that have begun operations in recent years, which may present challenges for them to realize economies of scale. To this point, many of the domestic flat glass products are commodities, with price being the most critical consumer selection factor.

Further processing of flat glass, such as laminating and coating, is still at low levels compared to Europe and North America. The quality of commercial developments has been improving, however, and in response to the need to cut carbon emissions, building regulations are expected to rapidly increase the use of value added solar control and thermal insulation glass in many parts of the country.

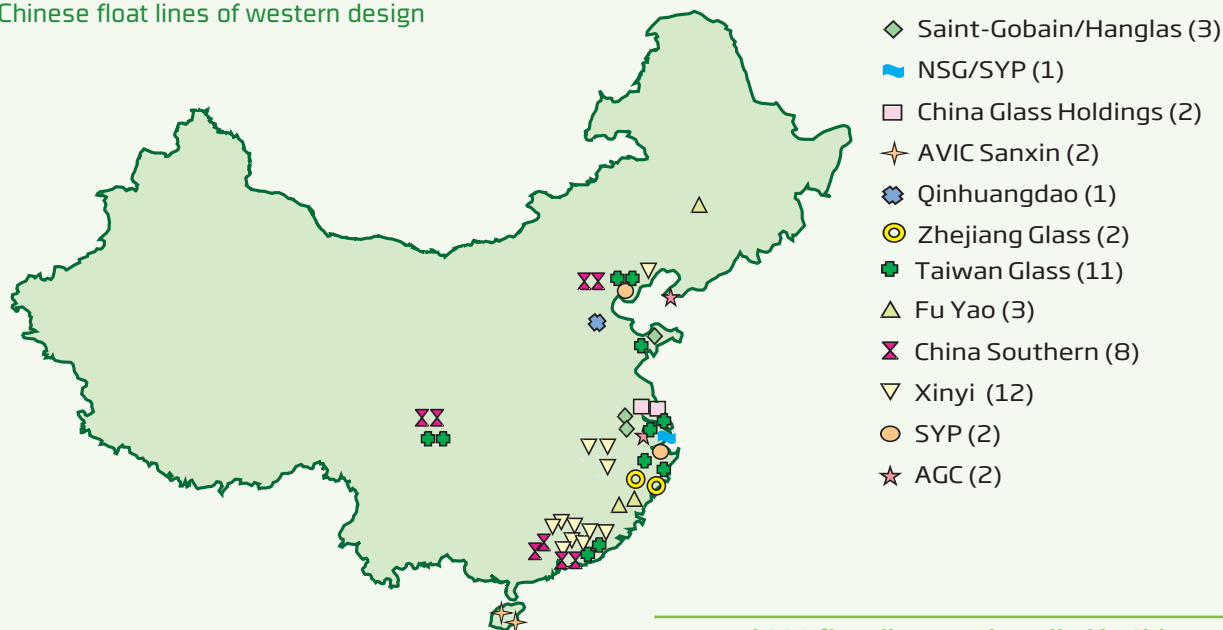
China 2010 float glass capacity by company



Total capacity, including lower quality float and sheet glass, was around 33 million tonnes in 2010, of which around 10 percent was sheet glass.

China accounts for more than 50 percent of global flat glass production.

Chinese float lines of western design



Around 220 float lines are installed in China, but only around 50 of these produce high quality float.

Former Soviet Union (FSU)

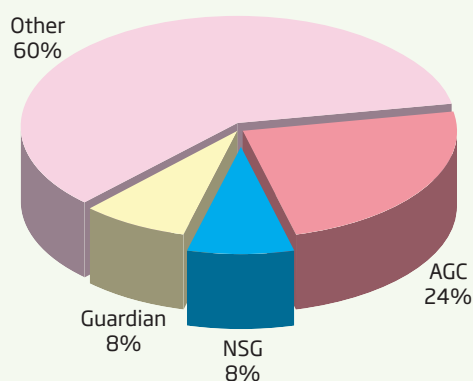
The Former Soviet Union (FSU) market described below refers to Russia, Ukraine, Belarus plus the former soviet republics of Central Asia and the Caucasus.

There were 22 flat glass manufacturing operations in the FSU as of 2010, 16 float lines and six still using sheet technology. Most of these plants, including all of the sheet glass operations, produce glass which is generally of a lower quality than the modern float glass production found in Western Europe.

The demand for both high quality float glass and value-added glass products, such as products with energy-saving features, continues to grow. The total market size in 2010 was approximately 2.6 million tonnes.

This demand has been mainly fueled by new build activity and residential refurbishment work. The growing quality expectation in the Russian economy, coupled with recent construction activity, provides considerable opportunity for float glass manufacturers, and competition in this market is expected to increase. However, current market conditions may affect demands for new or existing construction in Russia. A reduction in such demand could reduce demand for building glass products from previous levels.

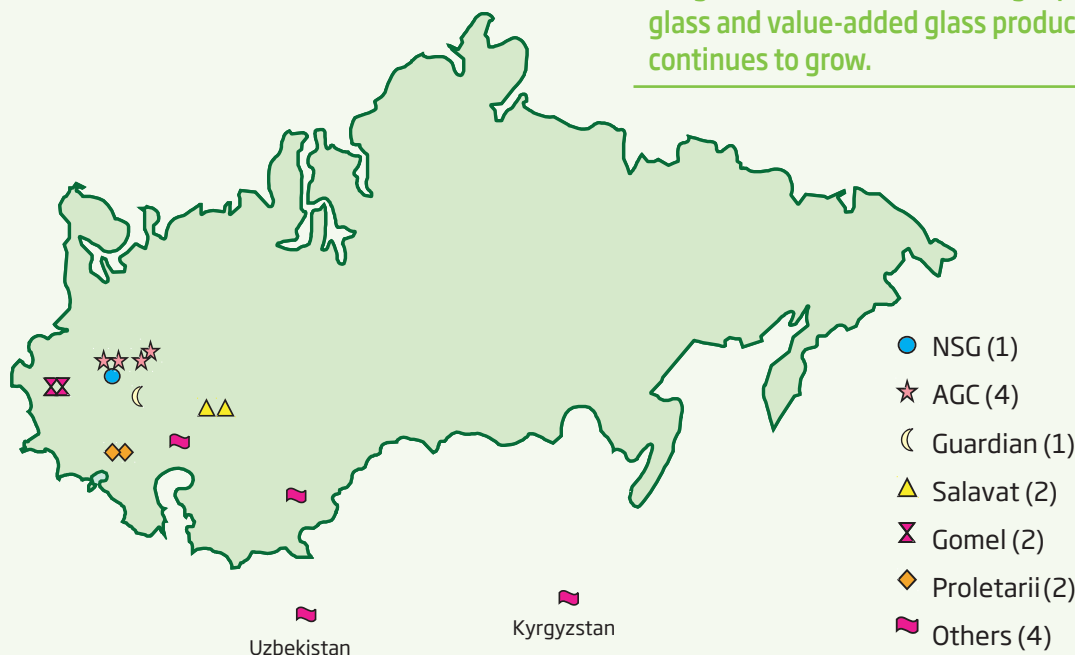
Former Soviet Union 2010 float/sheet glass capacity by company



Total installed flat glass capacity in the FSU was 2.5 million tonnes in 2010, of which just over 144,000 tonnes was sheet glass.

There are currently 22 flat glass manufacturing operations in the FSU, 16 float lines and 6 still using sheet technology.

Former Soviet Union float lines



Long-term demand for both high quality float glass and value-added glass products continues to grow.

Rest of the world

The Rest of the World is defined to include West Asia, Africa and Oceania.

This glass market is generally much less mature, with annual per capita consumption at approximately 1.5 kg in 2010.

Recent new float investments have been announced by Al-Obaikan in Saudi Arabia (started in Feb 2011) and MFG in Algeria due to start in 2012.

Furthermore, there is a greater proportion of sheet and lower quality float capacity, which is expected to be gradually phased out and replaced by high quality float over the longer term.

In many parts of the world, glass markets are still maturing and adopting value-added products.

1.6 Automotive

Market overview

There are two routes to market for automotive glass:

- Original Equipment (OE) supplied to Vehicle Manufacturers (VMs) for new vehicles.
- Automotive Glass Replacement (AGR) product, supplied to the aftermarket for retrofit purposes, usually following damage.

Globally, OE glass demand is estimated to be around four times that of AGR, though the proportion will vary from region to region.

Within the OE glazing market, by far the largest segment is light vehicles, generally defined as those vehicles up to three and a half tonnes in weight. Light vehicles (LV), which include all cars, light trucks and the various cross-over vehicle styles such as sports utility vehicles (SUVs) and people carriers, currently account for around 95 percent of global build.

It is the light vehicle market that is evaluated in the subsequent OE analyses.

In addition to light vehicles there are several niche vehicle segments; medium and heavy trucks, bus and coaches, and off-road vehicles such as tractors, diggers etc., each with distinctive glazing requirements.

Effectively three global automotive glass manufacturers, together with a number of smaller though in some cases regionally significant players, serve the world's OE and replacement markets.

The largest of the three automotive glass groups is Pilkington Automotive closely followed by AGC. Saint-Gobain is the third global player.

Two routes to market for automotive glass; Original Equipment (OE) and Automotive Glass Replacement (AGR).

OE light vehicle market

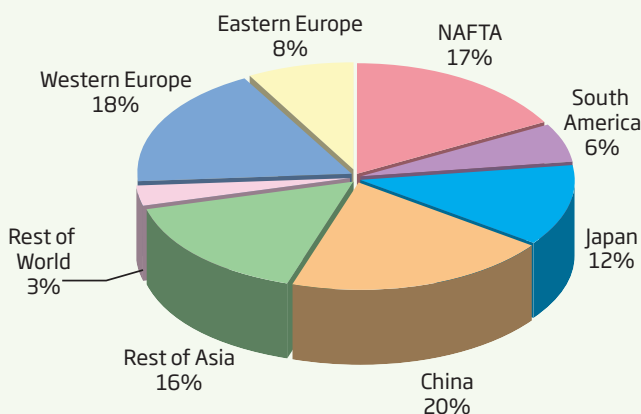
Light vehicle production in 2010 was 72 million, of which 35 percent was in the two main markets of Western Europe and North America. Build in Japan contributed a further 12 percent.

Not only do these three regions account for 47 percent of global LV production, but they are also the domiciles of most of the world's VMs and as such are the centers for new vehicle development.

Glazing continues to play an important part in vehicle design, providing a combination of aesthetic, functional and structural properties. The VMs are increasingly looking to their glazing suppliers to play a key role in the vehicle development process. Few automotive glass manufacturers have the combination of technical capability and the appropriate geographic presence to play this role to the full.

Western Europe and NAFTA produced 35 percent of the world's light vehicles in 2010.

Regional light vehicle build



Reflecting the importance of both technical capability and geographic presence in serving the light vehicle market, around 65% of global demand is supplied by the three global automotive glass groups, the NSG Group, AGC and Saint-Gobain with its strategic partner Central.

Around 65 percent of global demand is supplied by the three global automotive glazing groups.

Other regionally significant suppliers in 2010 were: Fuyao, the largest Chinese supplier and now growing outside its home market; PGW (formerly PPG) with operations primarily in North America; VVP, the glazing division of Mexican company Vitro; privately held Guardian Industries with operations in the US and Europe, and Zeledyne, the North America-based former Ford Glass/Visteon business.

In addition to the major manufacturers identified, there is also a fairly short industry tail comprising smaller automotive glass manufacturers. Of these smaller players a few independent producers are more focused on specialist/niche OE supply. Others, often affiliated with flat glass manufacturers in developing markets, are more limited to local OE supply. There are also a handful of small automotive glass processors primarily serving the aftermarket.

The last few years have seen a reversal in the trend to customer consolidation, which by 2004 had the top six VMs and their affiliates comprise 80 percent of the market.

Subsequent restructuring at GM and DaimlerChrysler involved divesting their respective stakes in Fiat, Suzuki, Subaru, Isuzu, Mitsubishi and Hyundai. Then came Daimler's sale of its stake in Chrysler and Ford's divestment of the Land Rover and Jaguar marques to the Tata Group. The most recent changes in the wake of the global recession include Fiat's purchase of Chrysler, Ford's sale of Volvo Cars to Chinese VM Geely and the significant downsizing of its stake in Mazda, and GM's divestment of Saab to Spyker.

In 2010, the six largest VMs with their affiliates accounted for 57 percent of global production. The principal brand memberships of the major VM groupings are listed overleaf.

In 2010, the six largest VMs, with their affiliates, accounted for 57 percent of global production.

Automotive customer groups

BMW Group

BMW Mini
Rolls Royce

Daimler Group

Mercedes
Maybach
Smart

Fiat Group

Alfa Romeo
Chrysler Dodge
Ferrari Fiat
Iveco Jeep
Lancia Maserati

Ford Group

Ford Lincoln

Fuji Heavy Group

Subaru

Geely Group

Geely Volvo Cars

GM Group

Buick Cadillac
Chevrolet GMC
Holden Opel
Vauxhall

Honda Group

Acura Honda

Hyundai Group

Hyundai Kia

Mitsubishi Group

Mitsubishi

Mazda

Mazda

PSA Group

Citroën Peugeot

Renault/Nissan Group

Infiniti Dacia
Nissan Renault
Samsung

Suzuki Group

Maruti-Suzuki
Suzuki

TATA Group

Land Rover Jaguar
Tata

Toyota Group

Daihatsu Lexus
Scion Toyota

VW Group

Audi Bentley
Bugatti
Lamborghini
Seat Skoda
VW

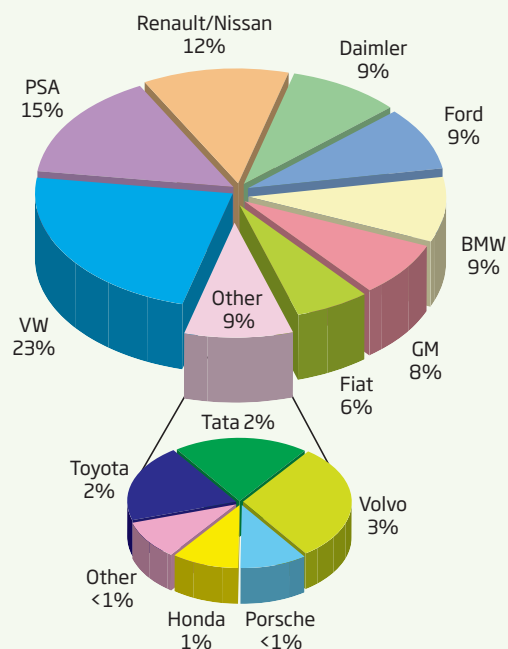
Europe

Even with the market turmoil of the past three years, the European OE market remains the largest (26 percent of global production), and its customer base is the most diverse of any region, with all of the world's major VMs having a production facility there.

In 2010, Western Europe accounted for almost 70 percent of the region's total production, though Eastern European vehicle build, which includes the major vehicle producing countries of Russia, Poland, the Czech Republic and Turkey, continues to increase in significance.

Western Europe has a broad and well-balanced customer base as shown to the right, with successive Japanese investment in recent years supplementing the existing presence of the traditional European VMs.

2010 light vehicle production Western Europe - 13.2 million

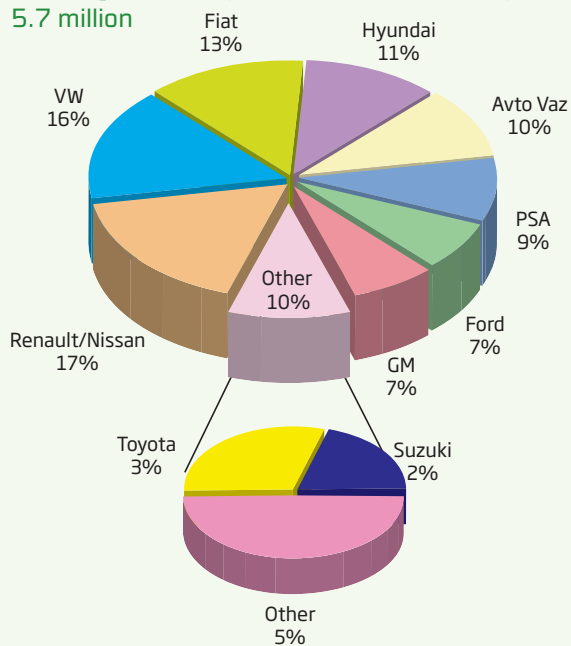


The opening up of the Eastern European market since the 1990s has seen increased investment from Western, Japanese and Korean VMs, following that of companies such as Fiat, GM, Renault and VW.

OE glazing supply in the Western European OE market is predominantly by the local operations of Saint-Gobain, Pilkington Automotive and AGC. A few smaller manufacturers, including Guardian, Soliver and Rioglass, together with a small amount of imports from Fuyao, PGW and Siseam, supply the remainder of the Western European market (~14 percent). Local independent glass processors are believed to have a larger share of certain Eastern European markets.

The European OE market is not only the largest, but its customer base is also the most diverse of any region, with all of the world's major VMs having a production facility there.

2010 light vehicle production Eastern Europe - 5.7 million



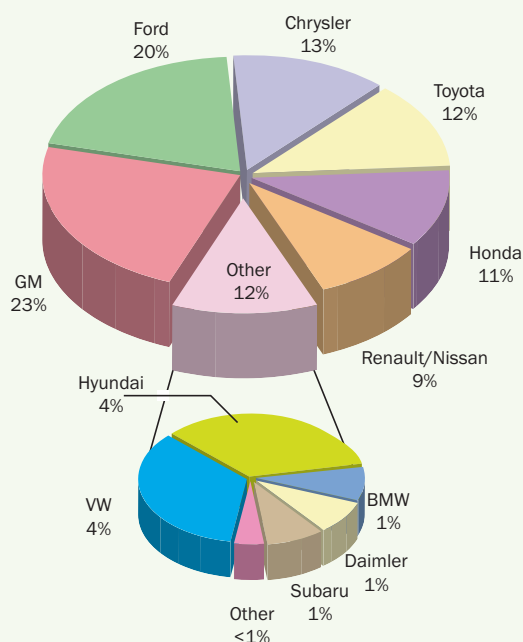
North America

Even with significantly increased production in 2010 as its recovery path from recession continues, NAFTA remains in the world number three position with a vehicle build of 11.9 million units. Traditionally, this market has been the domain of the 'Big Three' vehicle manufacturers, GM, Ford and Chrysler, though in recent years their share has been eroded by the operations of Asian and European VMs. In 2010, the share of the 'Big Three' VM groups was down to 56 percent of the market.

The OE glazing supply base in NAFTA is one of the most diverse of all regions. Three companies have market shares estimated in excess of 15 percent; three more companies have shares in the range 6 to 14 percent, with all of the remaining suppliers having shares of less than 5 percent.

NAFTA comprises the third largest OE market in the world, with 11.9 million units built in 2010.

2010 light vehicle production NAFTA - 11.9 million



PGW, AGC and Pilkington Automotive are the leading suppliers in NAFTA, with fourth, fifth and sixth spots taken by VVP of Mexico, the strategic partnership of Saint-Gobain's Sekurit business and Central Glass's Carlex subsidiary, and Zeledyne (formerly Ford Glass). Privately held Guardian, together with imports, accounted for the remainder of the market.

Japan

In 2010, Japan remained the fifth largest automotive market in the world; behind Europe, China, North America and the Rest of Asia, with light vehicle production of 8.9 million.

Production in Japan remains the exclusive domain of the domestic VMs, with western VM involvement limited to equity stakes in the domestic producers. This includes Renault's 44 percent in Nissan and Ford's now much reduced stake in Mazda. To date, only two of the Japanese VMs, Toyota and Honda, have remained independent of equity investments by US or European VMs.

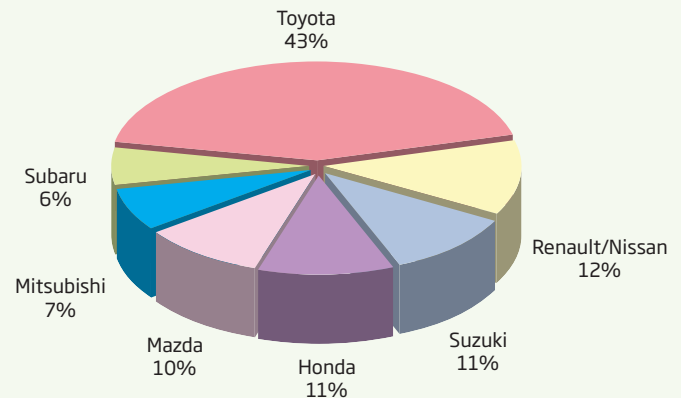
In Japan, as elsewhere in the world, Toyota is by far the largest of the Japanese VMs.

Supply of OE glazings in Japan is in the hands of the three domestic glass companies, AGC, NSG Group and Central Glass. AGC is believed to have just over half of the market and the NSG Group around 30 percent, with Central Glass taking the remaining share, except for a small amount of imports.

The need for the domestic glass companies to serve the Japanese VMs as they expanded their operations

overseas led, at least in part, to the strategic partnerships and subsequent investments between NSG Group and its now subsidiary Pilkington, and Central with Saint-Gobain.

2010 light vehicle production Japan - 8.9 million



Japan is the fifth largest Automotive market in the world, with light vehicle production of 8.9 million.

China

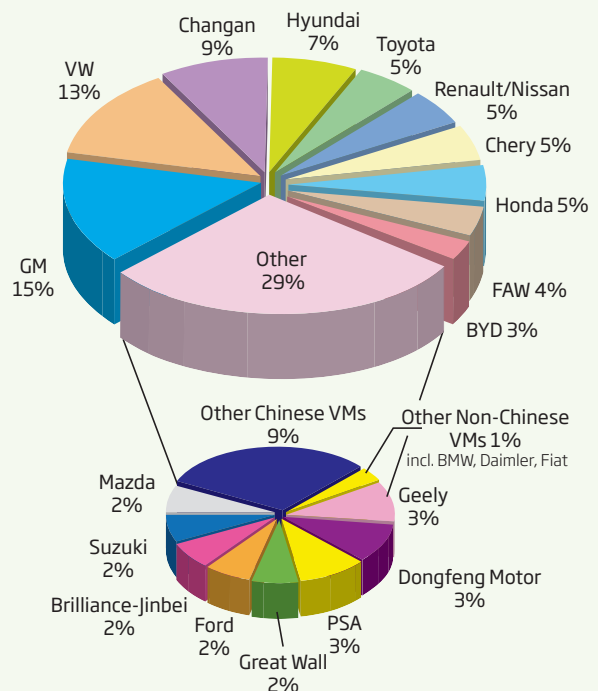
Consistent double-digit growth in recent years has seen China rise rapidly to be the second largest 'regional' market, behind Europe, and the largest in individual country terms, overtaking Japan and the US. In 2010, LV production in China grew by 32 percent, totaling 14.7 million units.

This recent phenomenal market development is on the back of inward investment by all of the major VMs, as well as organic growth by China's own domestic vehicle manufacturers. The Chinese automotive industry universally benefited from the government's stimuli of both the economy and industry, barely faltering as the rest of the world plummeted into recession before resuming growth at rates unheard of in other markets.

China is the second largest 'regional' market and the largest in individual country terms.

The leading glazing suppliers in China are; Fuyao, a Chinese company with an established history of serving overseas aftermarkets through exports, and which latterly has begun to export OE products, AGC through its now wholly-owned Chinese subsidiary, Saint-Gobain (Sekurit), SYPA, another domestic glazing supplier and Pilkington Automotive, through its three domestic operations.

2010 light vehicle production China - 14.7 million



Rest of Asia (excluding Japan and China)

At 11.2 million vehicles in 2010, Asia, excluding Japan and China, remains the fourth largest regional market. In automotive market terms, the region is not homogeneous, with several sub-market types being evident.

First, there is South Korea, whose well established automotive industry still transcends other regions, both in the form of exports and through vehicle assembly transplant operations elsewhere within and outside the region.

Secondly, there is the fast growing and potentially large market of India. Despite the recent major growth in vehicle production, vehicle ownership rates in India remain well below other developing markets. This market potential attracted some early investors, most notably Suzuki, and these early positions are now growing into a meaningful market presence. Latterly, many more European, Japanese and Korean VMs have invested in India.

The third group of Asian markets comprises the so-called 'Tiger Economies', which exhibited rapid growth through the early/mid 1990s. Vehicle production in Thailand, Indonesia, the Philippines, Malaysia and Taiwan grew significantly, benefiting particularly from inward investment by Japanese VMs.

Other sub-markets in Asia include the small mature Australian market and the new developing markets of Pakistan, Vietnam and Kazakhstan.

The Asian OE glazing supply base has its origins in local independent glassmakers. Whilst some still remain, increasingly these local players are now partnered with the major international glass companies.

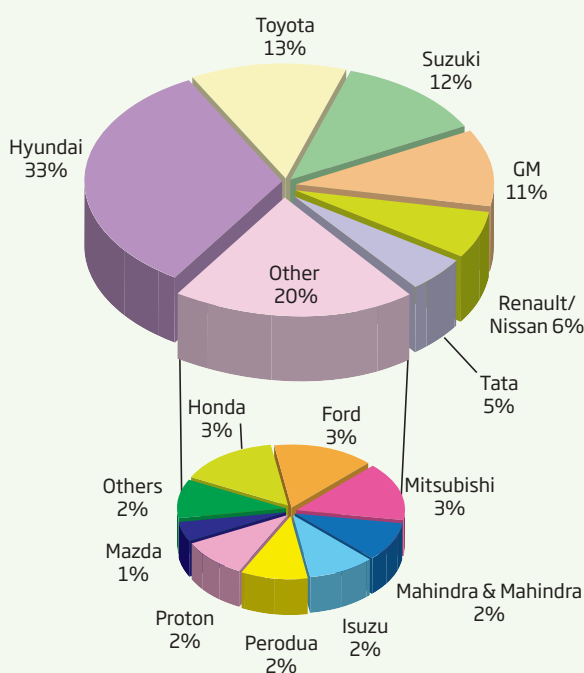
The Asian OE glazing supply base has its origins in local independent glassmakers, increasingly now partnered with the major international glass companies.

AGC led the way as far back as the 1970s, when it began to establish partnerships with local glass companies or investors. Such strategic investments were made in Thailand, Indonesia, India, the Philippines, Malaysia, Taiwan, China and most recently South Korea. Latterly, AGC has increased its stakes in several of these companies, moving to majority ownership positions. To a lesser extent, the other two Japanese glass makers, the NSG Group and Central, both followed suit, with NSG investing in automotive glass affiliates in Malaysia, Taiwan and China, and Central having a Taiwanese joint venture.

Before the acquisition, Pilkington had originally focused on China, where today Pilkington Automotive has three operations. Latterly it has also invested in India and the ongoing regional footprint is further enhanced by the other Pilkington Automotive interests of the NSG Group mentioned above. Saint-Gobain's investments were initially targeted on India and China, in partnership with local glass processors.

Saint-Gobain also has a presence in the Thai market, in partnership with a local company Toa. However, its most significant Asian position results from the stake in Hankuk, the South Korean market leader, taken in 1997 and now grown to majority share ownership.

2010 light vehicle production Asia (excl. Japan & China) - 11.2 million



South America

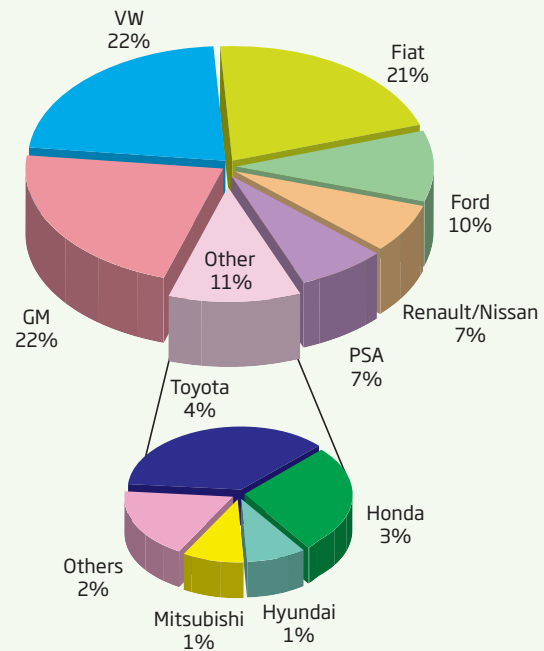
South America is the sixth largest vehicle-producing region in the world, with Brazil and Argentina together accounting for around 93 percent of regional volume. Brazil remains by far the most significant vehicle producing country in South America.

Traditionally, the South American market has comprised mainly European VMs, though an Asian presence is being built, principally by Japanese VMs. Three VMs together, VW, GM and Fiat, make up almost two thirds of the market.

The NSG Group, through its Pilkington Automotive operations in Brazil, Argentina and Chile, and Saint-Gobain, through its Brazilian and Colombian subsidiaries, together account for around 90 percent of South American glazing demand with the remaining supply coming from independent domestic processors and from imports.

South America is the world's sixth largest vehicle-producing region. Brazil and Argentina account for around 93 percent of regional volume.

2010 light vehicle production South America - 4.2 million

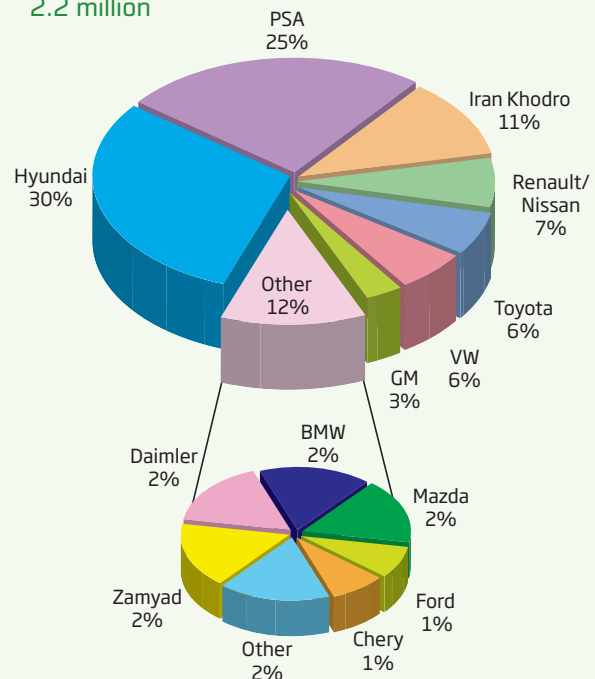


Rest of the world

Iran, South Africa, Egypt and Morocco comprise the principal OE markets elsewhere in the world, accounting for just 2 percent of global volume.

The South African market is principally served by Shatterprufe, the automotive glass subsidiary of domestic flat glass manufacturer, the PG Group.

2010 light vehicle production Rest of world - 2.2 million



2. Glass - a growth industry

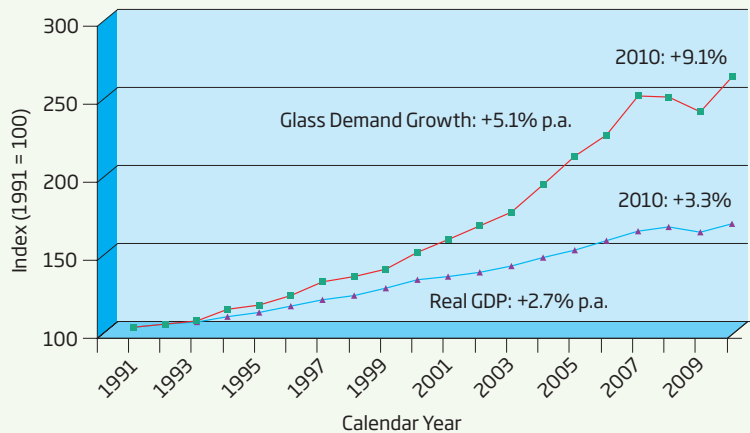
2.1. Global demand for flat glass

Over the long term, demand for float glass is growing at >5 percent per annum.

This growth is fuelled by the demand for building glass and automotive glass, which in turn is driven by economic growth.

Over the last 20 years, float demand growth has outpaced real GDP growth. Over the past 10 years, float demand has exceeded GDP growth by around 2.5 percentage points.

Global float demand grows >5 percent p.a. In 2010 demand grows by >9 percent



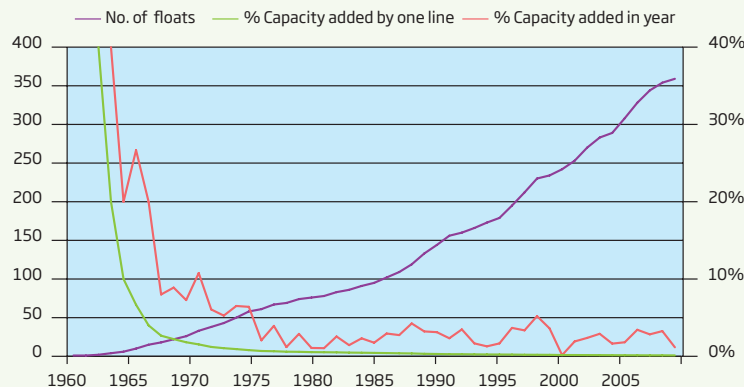
The world flat glass market is expected to reach almost 60 million tonnes in 2011, including 2 million tonnes of rolled glass, from the recession-hit 2009 level of 52 million tonnes.

Until this year, global float capacity utilization has ranged between 90 and 95 percent (virtually the practical limit for a network of float plants).

In 2008, global capacity utilization dropped significantly towards the lower end of this range, after a sharp tightening of demand due to the global recession. Recovery in 2009 and 2010 was supported particularly by strong demand growth in China and capacity reduction measures taken by the industry.

Despite further strong demand growth expected in 2011, utilization is expected to dip again due to further new capacity being brought on stream, especially in China. In practice, the industry may again choose to impose capacity reduction measures to support utilization. A further significant point is that each new float line that is added to the installed base represents a smaller percentage of installed capacity and is therefore likely to cause less of a disturbance to the supply demand balance. This can be illustrated by the following chart showing the effect of additional float capacity since the construction of the world's second line in 1962.

Incremental capacity - global



A new float line added in 1970 represented more than 3 percent of global float capacity. A new line in 2011 represents less than 0.3 percent of global installed capacity. Nevertheless, the impact of a new float line in certain territories can still be quite marked, at least in the short term, until the new capacity is fully absorbed by market growth.

In 2011, a new float line represented less than 0.3 percent of global installed capacity.

Global glass industry summary

- Over the long term demand is growing steadily in most regions
- The global recession caused a serious demand contraction in 2009 but global recovery was strong in 2010 and all of the lost ground was recovered. This recovery has been driven mainly by emerging markets, whereas demand in developed markets is still well below pre-recession levels
- Growth of value-added glass has the effect of reducing float capacity as output is effectively lower
- Global capacity utilization is expected to remain above 90 percent in the medium term
- The pace of capacity addition outside China has moderated recently, with eleven new lines on stream in 2010 but only three expected in 2011.

New float build program

The following table shows lines that have come on stream in 2010, and those planned to start-up in 2011. In addition, it is believed that more than 50 float lines will have come on stream in China in 2011 and 2012.

New Float Build Program

Country	Company	Start Year
Belarus	Gomel	2010
Russia	AGC	2010
Russia	YugRos	2010
Bulgaria	Sisecam	2010
Egypt	Saint-Gobain/ Sisecam	2010
Egypt	Sphinx Glass	2010
India	HNG Float Glass	2010
Vietnam	Chu Lai	2010
Vietnam	Trang an	2010
Saudi Arabia	Arabian United	2010
Turkey	Okan Cam	2010
Italy	Sangalli	2011
Saudi Arabia	Al-Obaikan	2011

Regional analysis

In the following analysis of regional glass markets the world is segmented into seven regions as follows:

**Europe • Japan • ASEAN
US/Canada • South America • China
Russia/Formal Soviet Union**

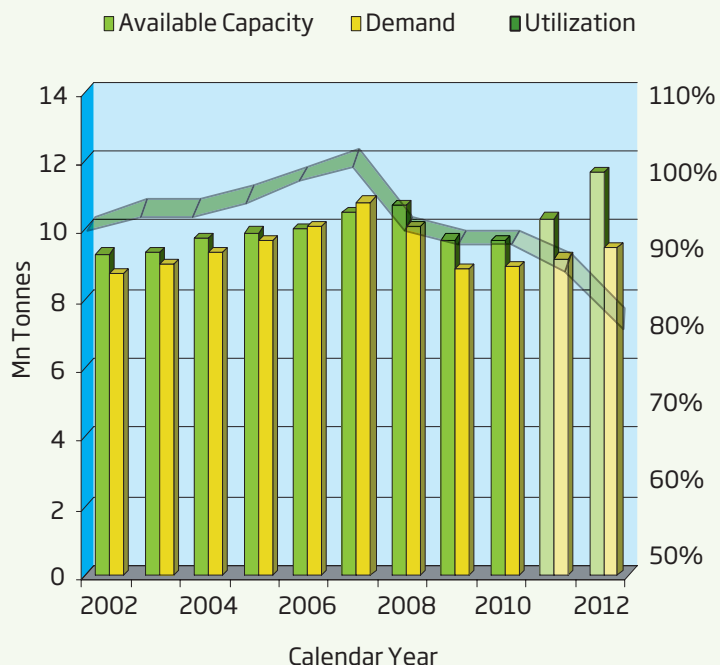
Analysis of demand and capacity utilization is on the basis of all sheet and float production.

Europe

Europe is defined as extending as far east as, but excluding, Russia, Ukraine and Belarus. To the south it includes Turkey.

Capacity utilization remained in the high 90 percent range from 2000 to 2007, but the recession which hit in the second half of 2008 led to a contraction in demand, while significant new capacity came on stream. Further new capacity, from projects begun prior to the recession, came on stream in 2010 and 2011 but the industry has moved to reduce overall capacity through extended repairs and other shut downs. Even so, utilization is expected to fall below 90 percent in 2011.

Europe capacity utilization



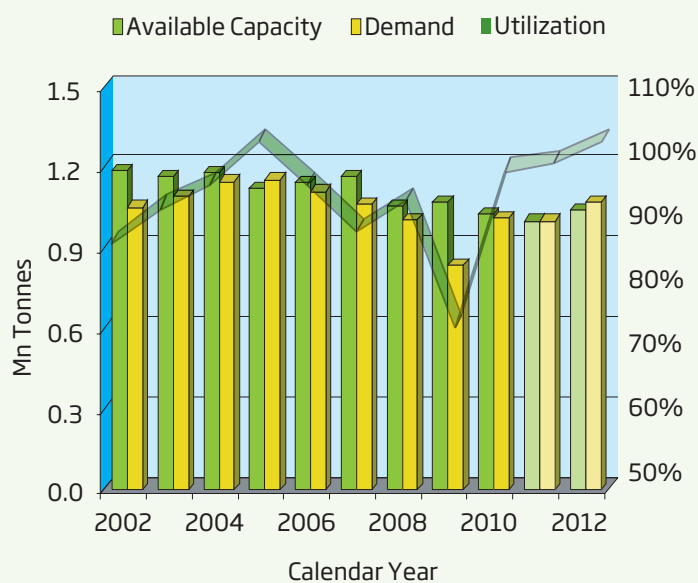
Japan

Demand in Japan has been essentially flat at approximately one million tonnes since 2000. The global recession drove demand below 850 thousand tonnes in 2009, but this recovered to just over one million tonnes in 2010, driven by strong demand in automotive and specialty glass sectors.

Available capacity has been in decline throughout the decade as lines have been mothballed, or converted to produce glass for specialist applications. Nevertheless, the fall in demand drove utilization below 80 percent in 2009.

The major earthquake and tsunami in early 2011 impacted industry capacity temporarily but had relatively little effect on demand. The affected lines were quickly brought back on stream and continued demand recovery will push utilization above 100 percent in 2011.

Japan capacity utilization



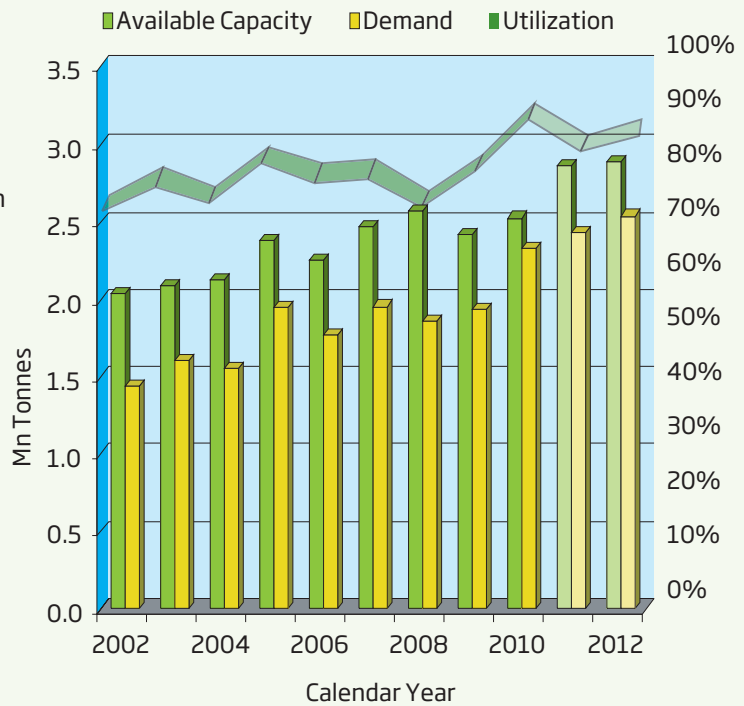
In Japan, capacity reductions are expected to push utilization above 100% beyond 2010.

ASEAN

Demand has been fairly volatile in the ASEAN region throughout the decade. In recent years, growth in production of solar energy modules has provided a significant boost to value-added glass demand. This has pushed apparent utilization above 80% but much of this glass is supplied from outside the region.

Capacity additions in 2010 and 2011 have added downward pressure to the real utilization of regional assets.

ASEAN capacity utilization



US/Canada

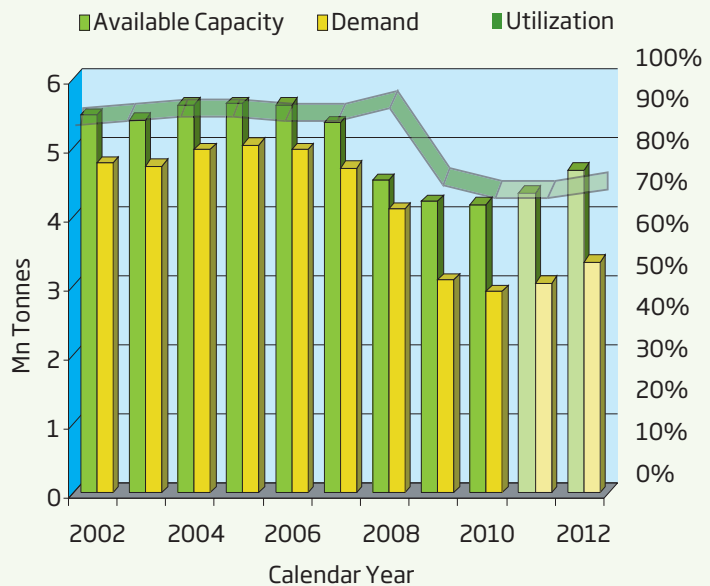
North America was the first region to fall victim to recession and demand has contracted sharply since the peak of 2006.

In North America, regional capacity utilization has fallen below 70 percent.

This is a similar demand picture to Europe but the crucial difference has been the corresponding reduction in capacity as lines have been taken out of action. Several facilities also underwent lengthy repairs or other forms of capacity reduction during 2009 and 2010.

Regional capacity utilization is believed to have bottomed out in 2010 and a long-term recovery is expected to begin in 2011.

North America capacity utilization

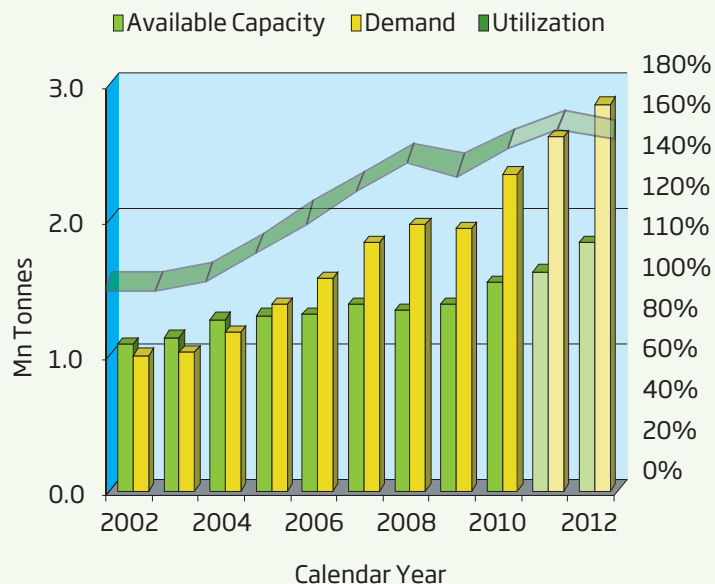


South America

South American glass demand has been steadily growing since 2003. This growth was interrupted temporarily by the recession in 2009, but normal growth rates have resumed quickly in 2010.

Regional capacity utilization reached around 150 percent in 2008 (the region is a net importer of flat glass), reducing in 2009 as new capacity came on stream in Brazil. It has since increased again to over 150 percent as demand continues to outpace capacity growth.

South America capacity utilization



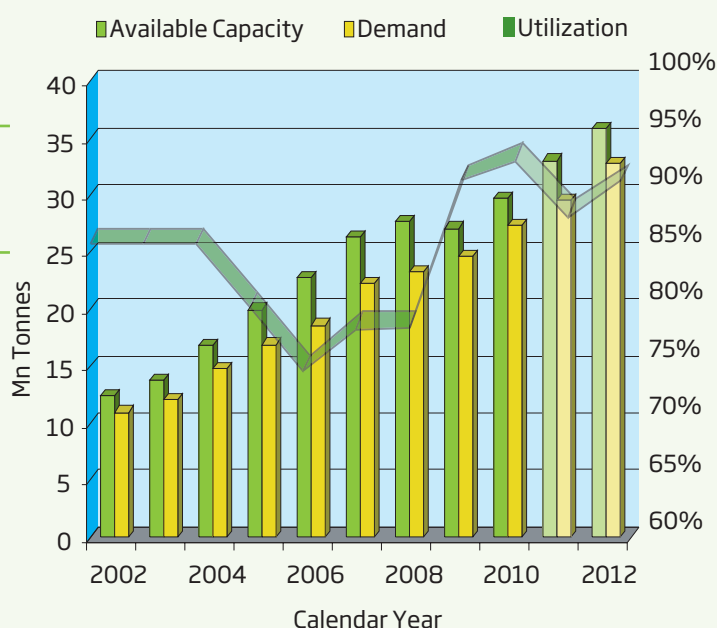
China

Since 2000, there has been a major float build program in China, and the number of float lines has increased to around 220. This resulted in a downturn in utilization to around 85 percent between 2005 and 2008.

In China, utilization is expected to stabilize as strong demand growth resumes.

Significant capacity reduction measures were taken in 2009, along with the deferral of several new float start-ups, in response to the global recession, but, in reality, domestic demand growth continued, albeit it at a lower pace. This resulted in a strong increase in utilization and the addition of new capacity has gathered pace in 2010, when around 25 new lines are expected to have come on stream. Further strong demand growth is expected in 2011, which will maintain utilization at around 90 percent.

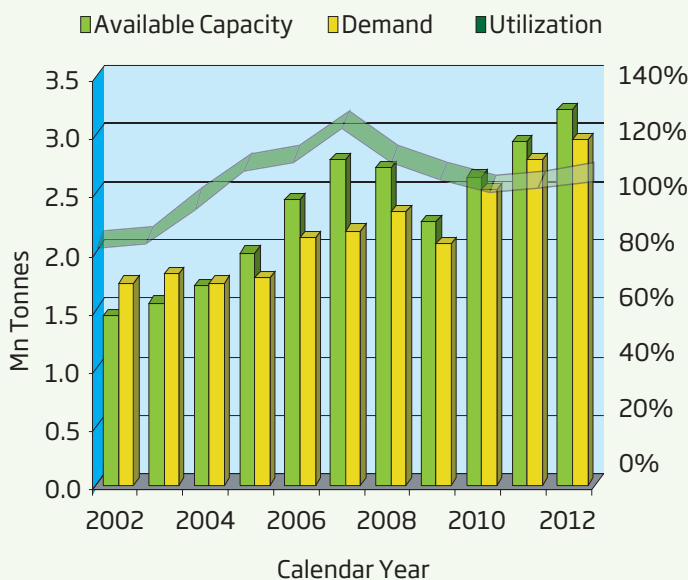
China capacity utilization



Former Soviet Union

Flat glass demand has grown robustly since the relative low point of 2000 up until 2008, with the market size more than doubling in eight years. Market demand fell sharply in 2009 but despite significant capacity additions in 2010, utilization is set to remain above 100 percent in 2011.

Former Soviet Union capacity utilization



2.2. Growth in Building Products

Growth in Building Products is fuelled by a number of drivers:

Construction

Glass is an integral building material for most construction projects. Virtually every new building requires glass. Both new building projects and the refurbishment of existing buildings call for large quantities of glass products.

Architectural trends

Architects are increasingly seeking to bring natural environmental factors into the interior of buildings by maximizing natural daylight. This has been achieved through the use of larger glazed areas in façades and roofs, and through entirely glazed façades where the glass is a structural component of the building.

In sunnier climates, the reliance on air conditioning, which would otherwise be increased by such larger glazed areas, is mitigated by the use of advanced solar control products which allow the sun's light into the building while keeping much of its heat out.

Refurbishment

Refurbishment of buildings accounts for around 40 percent of architectural glass consumption worldwide. In mature markets, windows in residential buildings are replaced every ten to twenty years.

Value Growth - Building Products

Demand	Growth drivers
Energy-saving (heating)	Energy-saving legislation and building regulations; reduction of energy loss from buildings, energy labeling of windows.
Energy-saving (cooling)	Energy-saving legislation, reduction of air-conditioning load in buildings, preventing non-air-conditioned buildings from over-heating.
Safety/ security	Increasing legislative requirement for safety glass in certain applications. Requirement for transparency combined with security features.
Fire	Requirement for good light transmission and protection compliance with regulations on fire protection.
Acoustic	Increasing noise levels caused by traffic, aircraft, etc., progressively backed by legislation.
Self-cleaning	Reduction in use of detergents, safety at heights, extension of product range and features to increase functionality in commercial and domestic applications.
Solar Energy	Demand for renewable energy, stimulated by government support and feed-in tariffs.

Energy efficiency

Over the past 25 years, in developed regions such as Europe, Japan and North America, the growing need for energy efficiency in buildings has transformed the markets for energy-saving glass and this is now being echoed in developing regions.

Targets for reducing CO₂ emissions have driven tougher legislation for energy saving glass. Building regulations in many countries now require insulating glass units (double or triple glazing) as standard, with energy-efficient low-emissivity (low-e) coated glass often necessary.

European building regulations continue to be the major driver for high performance and added-value glass, particularly in the area of energy efficiency.

In hot climates, there is an increasing recognition that reliance on air-conditioning can be mitigated by the use of advanced solar control glass. Window energy labeling systems have been established to promote energy saving glass to the consumer and provide a mechanism for financial incentives. There is also growing governmental support worldwide for renewable energy generation, including solar energy.

Energy legislation

As buildings account for around half of all energy consumed in developed countries, they have become the prime focus of attention in terms of legislation. In the EU, for example, targets have been set for reducing energy consumption by 20 percent, reducing greenhouse gas emissions by 20 percent and producing 20 percent of energy from renewable sources.

The recast of the EU Directive on Energy Performance of Buildings imposes a raft of obligations on Member States, including the requirement to upgrade their building regulations for energy at least once every five years. Furthermore, it requires all new buildings across Europe to be built to very high energy efficiency standards ('nearly zero') by 2020 and all existing buildings undergoing major renovation to meet minimum energy performance requirements.

Building regulations continue to be the major driver for high performance and added-value glass, particularly in the area of energy efficiency. In most countries there have been major changes to building regulations for energy efficiency, creating opportunities for added-value glass, and this is anticipated to continue in the future.

Low-emissivity glass

All central and northern European countries, and indeed some southern countries (such as Italy), have legislation requiring low emissivity glass in new buildings. Several countries also have legislation requiring low-emissivity glass in all replacement windows.

In the USA, the International Energy Conservation Code, which impacts on energy efficiency for buildings and specifically glass, was revised in 2009 and is due to change again in 2012. This is complemented by initiatives such as the US Green Building Code's environmental building rating system (LEED).

In China, the government has already introduced building regulations to improve the energy efficiency of new buildings, which should help to significantly increase the share of low-e glass in an insulating glass unit market of over 200 million m². In 2009, South Korea introduced a new regulation which effectively makes low-glass standard in new buildings.

In Northern European countries, triple glazing or '2 + 1' double window has become the norm. In some central European countries, the longer term plans of most governments include progress towards triple glazing as the regulatory norm, as zero and low energy buildings become common.

An example of the market-transforming effect of building regulations is the sharp increase in demand for low-emissivity glass in Germany in the 1990s from less than 2 million to over 25 million m². Even before it came into force in 1995, knowledge of the legislation drove the penetration of low-e glass in insulating glass units to around 50 percent. Low-e glass has now been standard in Germany for many years and the experience has been repeated in other countries such as the UK. The trend is being repeated across the globe, dramatically increasing the demand for low-e glass.

At a primary level, low-e glass earns revenues 40 percent higher than ordinary float glass.

For the primary manufacturer, low-e glass typically earns revenues 40 percent higher than ordinary float glass, so this substitution effect greatly improves the value added.

Solar control glass

Around the world, countries are increasingly turning their attention to air-conditioned buildings, in order to reduce energy usage and CO₂ emissions, thereby creating opportunities for solar control glass. These products have special coatings applied to their surface which reflect up to 75 percent of the solar heat while transmitting the majority of the visible light. This allows a bright and cool environment to be maintained inside a building with reduced requirement for air-conditioning. Products such as this can earn up to ten times the revenue per square meter of basic float glass. Their use will increase as climate change results in increased ambient temperatures, thus imposing greater demands on air-conditioning in buildings.

The Energy Conservation Building Code in India has introduced specific requirements for high performance solar control glass. Although currently voluntary, it is widely adopted in major cities and will become mandatory for all new and refurbished buildings in 2013. Japan, Italy, Poland and parts of the USA have also addressed this issue in some way within their regulations.

Energy labeling

Window energy labeling systems, which evaluate the total energy performance of windows, have been established in many regions, including the UK, Finland, Denmark, Australia and North America. These allow the consumer to identify the best-performing products - stimulating the demand for energy-saving glass, and provide governments with a criterion which financial incentives can be linked. The introduction of a window energy rating system in Japan is anticipated in 2012.

Renewable energy

The same energy efficiency drivers are also resulting in increased demand for photovoltaic and solar thermal energy panels, in which glass is an essential integral component. The EU Renewable Energy Directive sets a requirement for 20 percent of energy across the EU to be produced from renewable sources by 2020. It also includes mandatory targets for each EU Member State.

Feed-in tariffs in countries such as Germany, Spain, Italy and Greece have made it economically attractive to feed power into national grid systems. Authorities in Japan have indicated likely support for homeowner solar installations and US tax incentives are adding further impetus.

Safety - toughened, laminated and fire protection

Growing awareness of safety has also driven building regulations for laminated, toughened and fire protection glass, which further enriches the product mix of the industry. Growth in use of laminated glass has also been driven by developments of improved sound insulation of some laminated products.

Technical applications

Glass is increasingly being used in a range of applications which require a high degree of functionality.

One of these fast growing applications is Thin Film Photovoltaic (PV) panels for Solar Energy, where coated glass is used as an integral active component of the device. Other consumer applications, such as touch screen devices, again use glass as an active integral component.

Although small today, in comparison with glass demand for mainstream building applications, these applications require glass of much higher value and have the potential to achieve significant scale.

2.3. Growth in Automotive

Structural trends

Various structural trends have affected the automotive glazing industry in recent years, both from the customer and the supply side.

One such trend had been the consolidation in the OE customer base; the vehicle manufacturers. VM mergers and acquisitions, together with some organic growth, saw the top six VM groups in 1992; (GM, Ford, Toyota, VW, Nissan and Chrysler) increase their combined global market share from 57 percent to 80 percent by 2004. However, industry

restructurings over the last few years now see a slightly differently constituted group of the six largest VMs accounting for 57 percent of global light vehicle build.

The concentration of the customer base historically has been mirrored on the supply side and automotive glass is no exception. Here, acquisitions, strategic partnerships and organic growth have resulted in the three global glass supplier groupings, the NSG Group, AGC and Saint-Gobain/Central, increasing their combined global market share from 49 percent to an estimated 65 percent.

Alternative consolidation trends can be expected as VMs seek to maximize leverage of their assets through partnerships, as well as taking strategic opportunities in developing markets. VMs will continue to look to their key suppliers to support them as they move into new markets.

Increased requirements by the VMs on automotive glazing suppliers favor those, such as Pilkington Automotive, able to offer:

- technical capabilities - shaping, optics, design feasibility/simulation
- global reach
- capital investment in support of both volume and developing technologies

A further industry trend, resulting from the VMs' drive to reduce costs in their core assembly operations, is the assumption by suppliers of activities previously undertaken by the VM.

Increasingly, automotive glass suppliers are becoming involved in the sequencing of product for 'just in time' delivery to the VM's assembly line. In some cases this may even involve the supplier working on the VM's line.

Demands on the glazing manufacturers are also becoming more intense, as VMs seek both to update their product ranges more frequently and to shorten the time taken to develop and bring their new models to market. To this end, major suppliers are today playing a key role in the design process, working closely with the VM in the early stages of development.

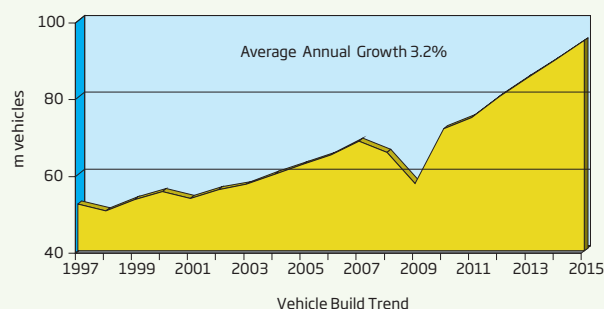
One aspect of the VMs' consolidation and globalization is the additional purchasing pressure this can exert on the supply base, particularly in an environment where cost reductions are a priority. Whilst not immune from such pressure, the glazing suppliers, such as Pilkington, increasingly work constructively with the VMs to identify areas of potential savings, ultimately providing benefits to both parties.

Automotive glazing demand drivers

OE Market

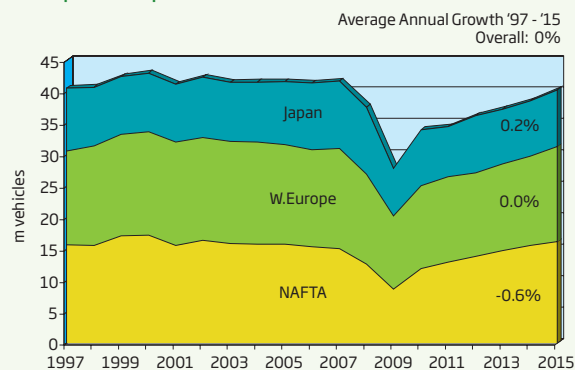
The basic driver of demand for any supplier to the OE industry is vehicle build. As can be seen in the chart below, historically the industry has exhibited steady growth, averaging 2.5 percent per annum in the 13 years to 2010.

Global light vehicle build - 1997 to 2015



However the unprecedented downturn that hit the industry in 2008 - 2009 was so severe as to take global demand down to levels experienced in 2003, effectively reducing the historical growth rate closer to 1 percent. The recovery that is now underway together with natural growth in developing markets, is currently expected to restore long term average annual industry growth to 3 percent by 2015.

Light vehicle build 1997 to 2015, NAFTA, Western Europe & Japan

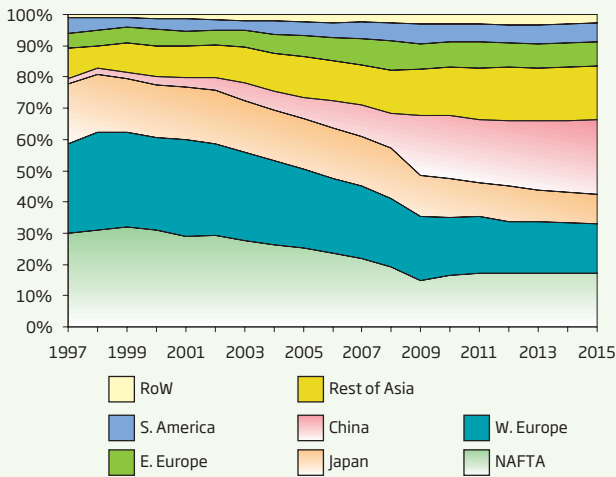


Despite the higher growth of the newer, developing markets, the three large developed markets; Western Europe, NAFTA and Japan, will retain a fundamental importance to the automotive industry for many years to come; not only because of their size, but also because they remain principal centers for new model development for all of the major VMs. The impact of the economic crisis on these mature markets was so severe that the volumes lost during 2008 and 2009 are unlikely to be fully recovered within the next four years.

The increasing relative importance of developing automotive markets is evident from the chart below. Together, the developing regions of Asia (excluding Japan), Eastern Europe, South America and the Rest of the World comprised 22 percent of global vehicle

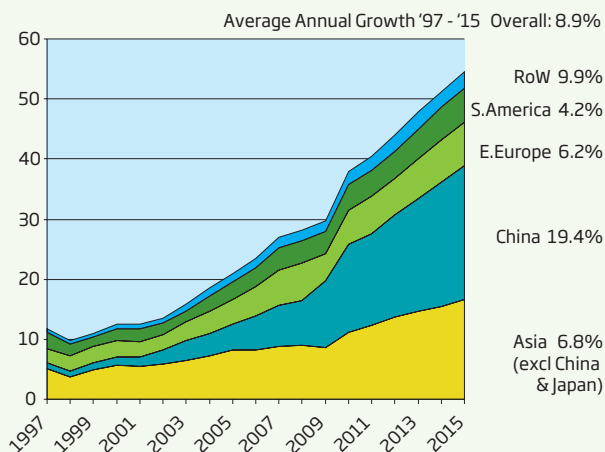
production in 1997. By 2010 their share had risen to 53 percent and is expected to increase to 57 percent by 2015.

Global light vehicle build 1997 - 2015



The annual average growth of these combined developing regions between 1997 and 2010 was over 9 percent. As growth in China moderates going forward, average annual growth in the developing markets through to 2015 is expected to reduce slightly to around 7 percent per annum.

Light vehicle build - 1997 to 2015 developing markets



Of the developing regions, China has been the best performer to date, exhibiting average growth of 24 percent per annum since 1997. Vehicle build in both Eastern Europe and the Rest of Asia has also shown good growth averaging 7 percent per annum since 1997.

All of the developing markets will continue to be the source of the global industry's growth. Though future rates will reduce from the routine double-digit figures previously experienced in some markets, the combined average growth across these markets is currently expected to exceed 7 percent per annum over the five years to 2015.

However, glazing demand driven by vehicle build growth is only part of the automotive story. There are three other drivers of the automotive glazing industry, the first two of which directly impact the OE market, both in terms of volume, and importantly, value.

The first of these additional drivers is the growth in the amount of glass used per vehicle. Key to understanding this trend is recognition of the change in vehicle styling and features as a result of technology advances and public opinion. Generally, larger vehicles for replacement models, taller vehicles, new vehicle apertures and new market segments have brought about an increase in the amount of glazing used. The global growth for the midsize vehicle segments has led to vehicle manufacturers using more glass to generate a greater impression of light and space within smaller vehicles.

Environmental considerations are also impacting the amount of glazing in vehicles with reduced installation angles for windshields and backlights providing improved aerodynamics, but requiring larger/taller parts.

Over the last 35 years, glazing area on equivalent models has increased in the order of 50 percent. Average windshield glazed area has increased by over 60 percent over the same period. With the use of large area rooflights increasing significantly year on year, it is clear that glazing is being used as an exterior styling feature in addition to a tool to increase the feeling of light and space within a vehicle.

Due to the constantly rising expectations of consumers and increased focus on environmental responsibility throughout the major global markets, small SUVs, cross-over type vehicles and small/mid-sized cars are growing in popularity. A greater number of vehicle models with lower volumes per model means that greater differentiation is happening. Increased flexibility is needed as the market evolves and VMs are using styling as a vital selling tool.

Glazing is critical to vehicle styling and offers stylists a fantastic opportunity to influence the appearance of a vehicle and fundamentally, vehicle side glazing is being used to develop clear design aspects for the side of passenger vehicles.

There can be anything from four to more than 13 glazed apertures on current light vehicles, many fundamental to the overall style and appearance of a new vehicle.

There can be anything from four to more than 13 glazed apertures on current light vehicles, many of which are fundamental to the overall style and appearance of a new vehicle. In particular, a vehicle's frontal aspect plays a huge role in terms of styling and the increasing use of panoramic and cielo windshields and rooflights is a key differentiating feature to bring value back into the glazing.

Europe and North America are currently leading the way with the adoption of laminated side-glazings for increased vehicle comfort and security. This increases glass usage through the replacement of monolithic side glazings by two plies of glass in each aperture and contributes significantly to the sales value of side glazings.

The second additional driver of business growth in automotive glazing is the increase in value-added content now being delivered by the leading suppliers to the OE industry.

Vehicle manufacturers are looking at ways for profit improvement and differentiation through products and features that the end user finds value in. Value-added also covers features in the glazing that allow a vehicle manufacturer to improve design, water management or make assembly operations easier or quicker.

Value-added product features would include: advanced acoustic control; solar control properties reducing solar heat gain; de-icing and de-misting capabilities; integrated antennas for radio, TV, cell phone, navigation etc.; integrated rain and light sensors for automatic wiper or headlight activation; hydrophobic and hydrophilic coatings for improved visibility, to name but some.

Value-added activity includes the supply of a complete glazing solution rather than just a piece of glass. Such systems use innovative finishing technologies, including encapsulation, extrusion and aesthetic functional trims, which enhance the vehicle's styling and in certain cases, aerodynamics, as well as adding functionality and improving the VM's productivity when glazing the vehicle. Today, glazing manufacturers are increasingly taking responsibility for the design and assembly of such complex glazing modules, for example, integrated tailgates for estate, crossover, MPV and SUV vehicles, including the glass, hinges, struts, wiper and latching mechanisms.

Equally, the glazing installation may simply require the prior fitting of locating clips to the glass. Again, this 'assembly' activity is increasingly being undertaken by the glazing supplier.

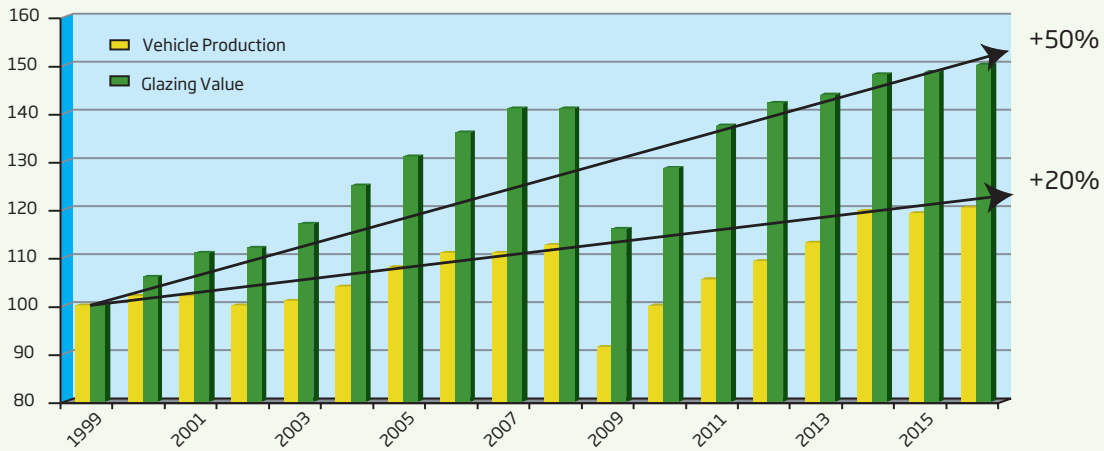
As environmental responsibility plays a greater role in world affairs, regulatory requirements are likely to push the value of a vehicle glazing set up significantly through the introduction of high performance solar control glass products, including infra-red reflective windscreens and very high performance solar absorbing glass compositions. How regions of the world adopt CO₂ reduction glass technologies is yet to be fully understood.

Value Growth - Automotive

Demand Style	Growth drivers
Innovation	Designers see glazing as a crucial element in designs to differentiate vehicles. New features and functions provided by glass such as the ability to control light and heat levels.
Security	Crime and vandalism increase the need for security, provided by laminated side, roof and rear glazings.
Comfort & Convenience	Larger glass areas require tinted and coated glazing to reduce solar gain and air-conditioning load. Acoustic control through advanced laminated glasses improves driver comfort.
Environment	The move towards more efficient vehicles and new drive trains, creates new opportunities for higher value glass products.
Integrated Systems	Modular assembly is moving the supply requirements from glass only to fully integrated systems including antenna arrays, electronics systems and integral trim.

By way of illustration, the chart overleaf shows the relationship between the growth in the number of vehicles built in the main European markets since 1999 and the growth in the value of the glazing in those vehicles.

European light vehicle production versus glazing value - 1999 to 2016



By 2008, vehicle growth and glazing value growth has been 13 percent and 41 percent respectively. By 2016, equivalent growth numbers are estimated to reach 20 percent and 50 percent. The rate of adoption of the different types of value added features will however vary from region to region. In North America,

for example, glazing systems are likely to be of greater importance, whilst Japan will lead on certain kinds of integrated antennas.

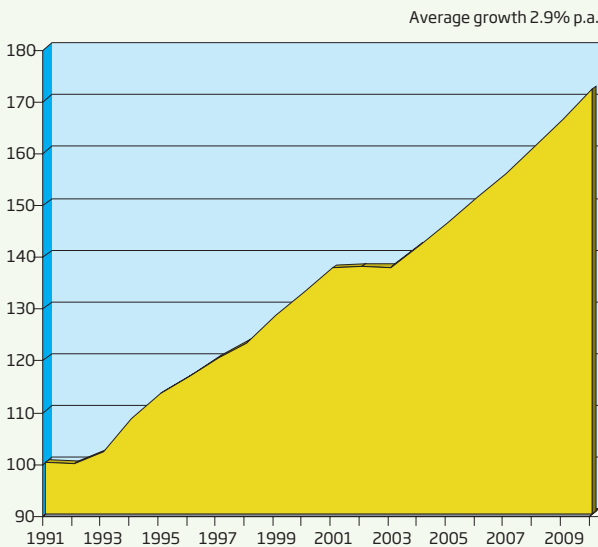
A more detailed explanation of Automotive value-added products and services can be found in section 3.4.

AGR market drivers

The third area driving overall automotive glazing demand is the replacement (AGR) aftermarket market. Here, market demand is determined by the number of vehicles in use and a replacement rate, which in itself will vary from one geographic market to another, depending upon the combination of a range of factors.

Principal influences on replacement rates are: average miles driven, speed, road surface conditions, climate, disposable income, vehicle crime levels, national legislation, repair/replacement ratio and insurance company policy.

Global AGR demand - 1991 to 2010



Glazing replacement tends to be greatest within the well-developed markets of Western Europe and North America, often driven by annual vehicle roadworthiness inspections, typically with rates in the 6 to 8 percent range. By way of contrast, the replacement rate in Japan is lower, particularly for windshields, due to the country's lower vehicle usage as opposed to its relatively high vehicle ownership.

Due to the relatively higher levels of accidental breakage of windshields from objects thrown up by vehicle wheels versus breakages of other glazings resulting from collisions or theft, aftermarket demand is normally heavily biased towards laminated rather than toughened glass, typically a ratio of around 3:1. This leads to a higher average value per piece of glass than in the OE market.

Additionally, the styling/design influences and value-added features previously described as driving glass business in the original equipment market, are increasingly having a positive impact on the aftermarket. As can be seen from the chart (left), long term industry growth in AGR volumes alone is estimated at around 2.9 percent per annum.

Long term growth in AGR volumes estimated at around 2.9 percent per annum.

Specialized Transport

The Specialized Transport market comprises a number of sectors:

- Truck (greater than 3.5 tonnes)
- Bus and Coach (including recreational vehicles)
- Off-road (including agricultural and construction vehicles)
- Railway (including subway, light rail and heavy rail)
- Marine (including small leisure craft to luxury cruise liners)
- Micro cars

These sectors are made up of a consolidating base of regional vehicle makers and assemblers and some are now major players on a global scale.

Global truck build 2010 ~2.5 million

The truck sector is by far the most consolidated and, of all the sectors, can be most closely compared with the OE customer base in terms of its global spread and organization. VMs are expanding through global JVs, particularly in China and Russia, but also by shifting their export production away from traditional Western European locations, closer to their global markets. Glazing requirements are becoming more complex as new fleet design incorporates improved visibility, safety and driver comfort features.

Truck production stalled as fleet replacement was delayed in response to the economic downturn, but very strong recovery experienced in Western markets along with continued momentum in developing markets. China and South America in particular are increasing rapidly, supported by investment in infrastructure, government incentives, the introduction of 'clean' legislation and the increase in freight.

Global bus and coach build 2010 ~ 400,000

The bus and coach sector has a relatively small number of chassis and engine suppliers, such as Daimler, Scania and MAN, which are strongly linked to the Truck sector. However, the assembly of the coachwork and body building is significantly more fragmented: There are a few large regional assemblers such as Evobus and MAN in Europe and Navistar in North America, and a large number of smaller independent companies usually supplying local markets. Some of the larger European manufacturers such as Daimler, Volvo Bus, MAN and Scania Bus are starting to expand operations into emerging markets through JVs and in the long-term this is likely to bring about more consolidation of the market.

The global Bus and Coach market is expected to grow at a steady but moderate rate, with significant regional variation characterized by strong growth in Asia and South America compared with relatively flat growth in the more mature markets such as Europe.

Large bus and coach production represents around 15 percent of annual truck production volumes but the build rates alone do not truly represent the sector's worth; the amount of glass in a 12-meter long bus or coach is typically ten-times that for a truck. Glazed areas have increased significantly with styling trends; the area of a windscreen alone can now exceed six square meters and glass is being incorporated into more areas of the bus such as roof lights above passenger seating to add more clarity in the models. The market drive for style differentiation and improved levels of driver and passenger comfort means that the trend for adoption of more value-added glazing applications is expected to continue in the developed markets and rise rapidly within the emerging markets.

Global off-road vehicles (glazed) ~ 1.5 million

The off-road agricultural sector is characterized by three major global players, John Deere, Case New Holland and AGCO. In contrast, the construction sector is still considerably more fragmented although there are some large global manufacturers such as Caterpillar, JCB and Komatsu. The off-road agricultural sector recovered from the downturn faster than expected, driven by high oil prices and the resultant demand for bio-fuel commodities. The construction sector is strong in South America and Asia driven by factors such as preparation for the hosting of Global events, reconstruction following the Japan quake and China urbanization projects. Western markets remain constrained by the economic pressures in the US and the Eurozone. Longer-term demand will grow across all regions, but with particular strength in South America and Asia.

The pressure to globalize further still exists in these major sectors. Western OEMs are shifting from their traditional bases to be closer to their customers. In addition, emerging markets are demanding higher quality and more complex products, which may be beyond the capability of the smaller, fragmented, domestic OEMs.

Rail

The Railway sector comprises a small number of rail transport and rail infrastructure manufacturers such as Alstom Transport, Bombardier, Siemens, Stadler and Kawasaki Heavy Industries. Railway demand is governed by national and municipal public transport policies and is project based. Higher fuel prices and the trend for more environmentally responsible mass transport systems is likely to lead to steady growth in demand for rail transport in the long-term.

Marine

The Marine sector covers leisure boats from 5.5 meters up to luxury cruise liners.

Leisure boats are manufactured by a small number of regional manufacturers such as Bella Boats, Fiskars, Nimbus and Windy, who take complex tempered or laminated glass directly from glass manufacturers or via aluminum/stainless steel framers. The demand for leisure boats is sensitive to economic conditions and reduced consumer confidence. Future growth will be closely linked to rate of the economic recovery in each region.

Luxury cruise liners are built by a small number of shipyards, based mainly in Europe. Although part of the marine sector, the glazing is more aligned to building products, typically comprising large glass panels and roofs and fire-resistant structures. Existing projects sustained the cruise liner market throughout the recession, but new orders were delayed as the companies owning and operating the ships waited to assess market conditions. Signs of market recovery can now be seen with European shipyards such as Fincantieri, STX Finland, Italian Fincantieri and Germanics Meyer Werft reporting new contracts. Traditionally, ship building capacity has been centered in Europe, but Korea is beginning to challenge this dominance. Japanese shipyard, Mitsubishi Heavy Industries, is also planning two giant luxury cruise projects.

Micro cars

Most of the major vehicle manufacturers are extending their range to include vehicles from the electric micro car sector. In addition, the sector has attracted many new entrants to the automotive business. Government incentives for cleaner cities are expected to promote high growth in this area in the coming years. Although the micro cars have a small vehicle footprint, they typically incorporate large and complex glazing areas.

The number of sectors in the Specialized Transport market and their relative lack of consolidation on the demand side have led to a preponderance of regional suppliers, with Pilkington Automotive being the only truly global supply option.

3. NSG Group - a glass industry leader

3.1 Corporate overview

The NSG Group, which operates under the Pilkington brand in Building Products and Automotive, is one of the world's largest manufacturers of glass and glazing products for the building and automotive markets, with manufacturing operations in 29 countries on four continents and sales in around 130 countries.

In the fiscal year ended 31 March 2011, the NSG Group reported sales of JPY 577,212 million (approximately euro 5 billion). Of the Group's consolidated sales, 41 percent were generated in Europe, 29 percent in Japan, 14 percent in North America and 16 percent in the rest of the world.

The Pilkington brand in flat glass

Pilkington was founded in 1826 as a partnership and became a private company in 1894. It remained a private company until 1970 when its shares were listed on the London Stock Exchange. Pilkington plc was de-listed from the London Stock Exchange in June 2006, when the company was acquired by the NSG Group; itself established in 1918.

The NSG Group has major market shares in most building and automotive product markets of the world, with a broad geographic reach, enabling it to respond to customers whose operations, particularly in the case of Automotive OE, are increasingly global.

In the financial year ended 31 March 2011, Building Products accounted for 43 percent of Group sales and Automotive for 46 percent of Group sales. In Building Products, the largest business is in Europe (accounting for 44 percent of the business line's sales).

The next largest business is in Japan, with 34 percent of Building Products sales, North America with 9 percent of Building Products sales and 13 percent in the rest of the world.

In the case of Automotive, Europe is also the largest business, with 47 percent of the business line's sales, followed by North America with 21 percent, Japan with 17 percent and 15 percent in the rest of the world.

Building Products

Building Products has manufacturing operations in 21 countries. Its largest operation is in Europe, but it also has major interests in Japan, North and South America, China and South East Asia.

This business encompasses the NSG Group's activity in manufacturing float and rolled glass, coating, toughening and silvering, the production of other processed building glass products for architectural and technical applications, including glass for the growing Solar Energy sector.

Automotive

Pilkington Automotive is one of the world's largest suppliers of automotive glazing products. It operates in three main sectors; supplying original equipment, aftermarket replacement glass and products for specialized transport.

Its footprint, including fabrication plants, OE satellite facilities and its AGR distribution network encompasses Europe, Japan, North and South America, China, South East Asia and India.

Employees

At 31 March 2011, the NSG Group had around 29,340 permanent employees working worldwide.

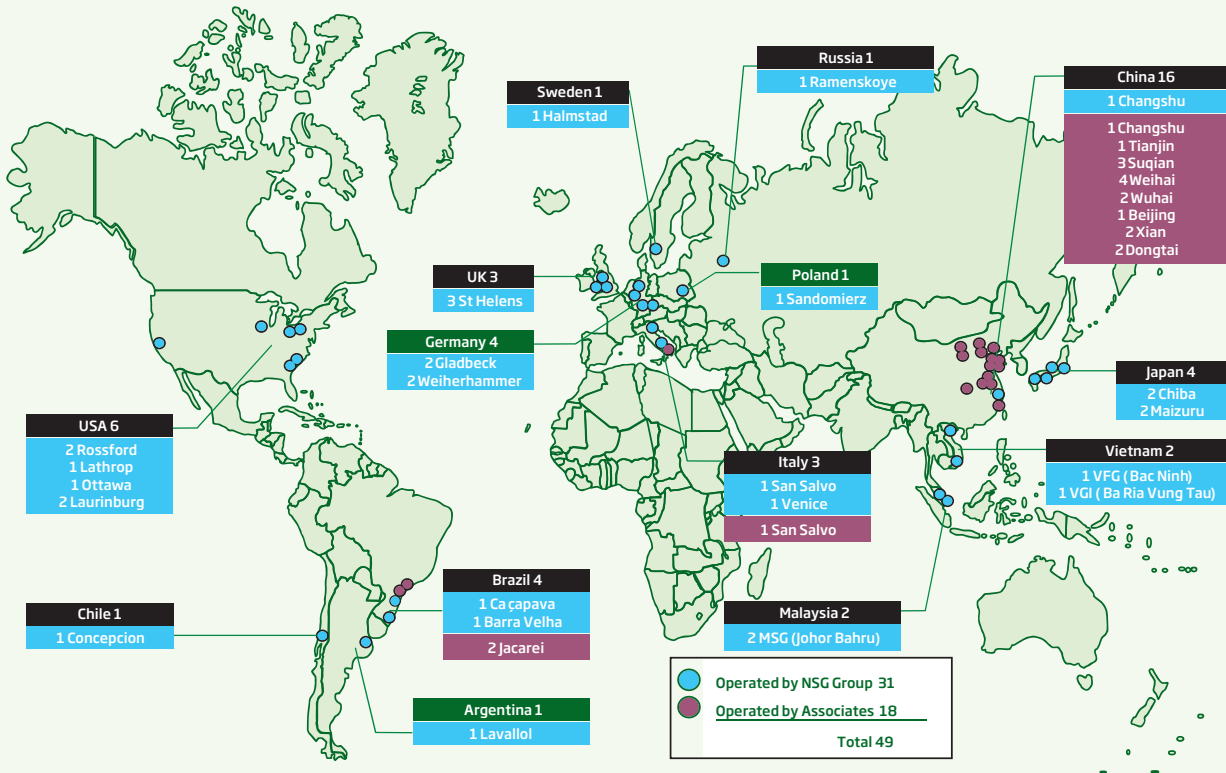
Management structure

The Chairman of the NSG Group is Katsuji Fujimoto. The President and CEO, responsible for managing the operations of the Group, is Craig Naylor. The Chief Financial Officer is Mark Lyons.

The worldwide Building Products business is managed by Clemens Miller, with regional Building Products managing directors for Europe, Japan, North America, South America, China and South East Asia. The worldwide Automotive business is managed on a global basis by Mike Fallon. The Specialty Glass business is managed by Keiji Yoshikawa.

3.2 Business profile

NSG Group global float manufacturing operations



Global reach

The NSG Group has a broad geographic reach. This global presence enables the Group to take advantage of diversified sources of raw materials and to capitalize on the advantages of the best local labor forces available. It also enables the NSG Group to provide excellent responsiveness in terms of product range, quality and delivery times to its customers, who, in the case of Automotive OE, have themselves become increasingly global.

The NSG Group is one of only four companies in the flat glass industry that can claim to be true global players, the other three being AGC, Saint-Gobain and Guardian. The Group is either already established or is developing operations in leading emerging markets, including China and India.

Broad manufacturing base

The NSG Group's manufacturing base includes float glass lines operating in Europe, Japan, the Americas, Southeast Asia and China, with Automotive operations covering all major markets worldwide.

The Group owns, or has interests in, 49 float lines, giving full coverage of the global market and providing the Group with advantages in terms of strategy, efficiency and effectiveness. During 2011, the Group announced the re-commissioning of a number of lines mothballed during the economic downturn. Some of these have been converted to produce products for Solar Energy applications. These include the VGI float line at My Xuan in southern Vietnam. In March 2011, the Group's UK5 float line was restarted, following its conversion for the production of Solar Energy products.

In May 2011, the Group announced plans to build two new value-added float lines in Vietnam to increase its production of specialist products to supply the growing Solar Energy and Touch Screen sectors. In addition, the NSG/SYP joint venture facility in Changshu, China (JSYP) will now be upgraded for the

manufacture of NSG **TEC™** products, with shipments from Changshu expected to begin in January 2012. These developments will bring the NSG Group's online coating float lines producing solar energy products to eight (one in Japan, two in North America, two in Europe, two in Vietnam and one in China) and those dedicated to UFF production to two (one in Japan and one in Vietnam) maintaining the Group's global leadership position in these fast-growing segments.

The Lirquen joint venture line in Chile was restarted in February 2011, a year after being put out of action by the Chile earthquake in 2010.

Intellectual capital

The NSG Group is a global leader in manufacturing excellence and innovation, notably in the areas of glass melting, glass forming by the float process, online coating and complex shaping technology, especially for automotive windshields and backlights. The Group invested JPY 10,692 million in R&D in FY2011.

The NSG Group owns or controls approximately 4,000 patents and patent applications, predominantly in the fields of float glass production and processing and

automotive glazing and also in the Information Technology field, and has access under license to patents held by third parties. The Group has also been active in selective licensing of its patents and technology, in the areas of online coating, encapsulation (of automotive glazing) and rain sensors (for automotive glazing).

Restructuring

In January 2009, the Company announced restructuring initiatives designed to address the economic downturn and to improve profitability going forward. These built on action already taken in response to sudden and rapid changes in the global economic environment. The overall objective of the program was to protect the business in the short term and to re-establish profit growth from FY2011 onwards.

The restructuring program was completed as planned during FY2010. 2,200 employees left the Group during FY2010, bringing the total headcount reduction to 6,700.

Innovation

The Pilkington brand is closely identified with technical excellence, having been associated over the past fifty years with most major advances in glass technology, including the invention of the Float Process. Notable Pilkington and NSG innovations over the years include:

- Energy-saving products such as Pilkington **K Glass™** and Pilkington **Energy Advantage™**
- Advanced bending processes for making car windshields in complex shapes to fine tolerances.
- Pilkington **Pyrostop™** advanced fire-resistant glass.
- **EZKOOL®**, **Sundym™** and **Galaxsee™** solar control glass for cars.
- Solar reflective automotive glazing.
- Pilkington **Solar E™**, clear solar control glass, preventing heat build-up in buildings.
- Pilkington **Planar™** structural glazing system.
- Pilkington **Spacia™**, vacuum glazing, high performance energy saving in a very thin unit.
- **UMU™**, switchable privacy glazing for internal partitions.
- The **3R™** clean air process for reducing nitrogen oxide emissions from glass furnaces.
- Pilkington **Activ™** dual-action self-cleaning glass.
- NSG **TEC™** range of glass for Thin Film Solar and Pilkington **Sunplus™** for the CSi Solar sector

Strategic Management Plan

The NSG Group has made good progress since the acquisition of Pilkington in 2006; moving from integration and consolidation to geographic expansion and value-added growth.

The Group's new Strategic Management Plan (SMP) is intended to drive the next stage of the Group's development. Announced in November 2010, the SMP covers FY2012 to FY2014. It sets out the main points of the Group's strategy to achieve profitable growth and realize the vision of the Company – 'Making a difference to our world through glass technology'.

The announcement of the plan followed a major strategic review, conducted in 2010, intended to sharpen the Group's operational focus and ensure that full advantage is taken of the synergies offered by an international Group headquartered in Japan.

Early investment opportunities were identified in a number of key projects with 12 to 24-month development timescales. The Group secured funding for these through the Share Offering launched in August 2010.

Funding from the share issuance is allowing the NSG Group to seize important investment opportunities in the technologies that will build a sustainable future, leverage its competitive position and strengthen its balance sheet.

Strategic Management Plan objectives

The aim is to create a thriving, innovative global enterprise, taking the Group to the next level in its development, by:

- Maximizing profitable growth while reducing net debt/earnings (EBITDA) ratio.
- Ensuring highest standards of ethics, safety, environmental responsibility and sustainability in all activities.
- Being innovative in all areas of operations.

The Plan is regarded as a 'dynamic' document, on which the Group is updating stakeholders on a regular basis.

Strategic Management Plan financial targets

The Strategic Management Plan includes clear economic targets to be attained by the end of FY2014.

- Attain 5 percent Compound Annual Growth Rate in sales
- Double operating profit (before amortization) as a minimum
- Increase EBITDA by 50 percent, as a minimum
- Achieve low double-digit percentage return on equity.

Strategic alliances/joint ventures

In addition to its substantial owned capacity, the NSG Group uses manufacturing and other joint ventures as a key strategic tool, promoting market development, business growth and risk sharing. In common with other major players in the industry, the Group has also used technical alliances with other glassmakers in order to promote and develop specific technologies and/or gain access to certain markets.

There are many examples of glass manufacturers sharing the risk of new float investments, either with other manufacturers or with financial partners in emerging markets, or in developed markets with secondary processors who wish to backward integrate to secure float purchases.

The NSG Group is no exception to this trend and the strategy of entering new markets and/or expanding existing operations in emerging markets has been prudent. Historically, there has been a preference for venture partners in countries it does not know well or where risk-sharing is important.

Growth strategies

Despite the downturn, the NSG Group is continuing with the strategy of pursuing carefully selected opportunities for profitable growth in flat glass. Recent growth strategies have fallen into three broad categories. Examples of each are listed below.

Business line strategic priorities for Building Products and Automotive under the SMP are:

Building Products

- South America – float expansion.
- Solar Energy – expansion to support photovoltaics.
- China – low-e energy-saving glass expansion.
- Fire Protection – investment in capacity in line with growing demand, to maintain leading global position.
- Expansion of other value-added growth products.
- Build on technology base to expand technical applications.

Automotive

- South America – toughening expansion.
- Mexico – laminating growth.
- Eastern Europe – laminating and toughening expansion.
- Expansion of AGR business, particularly in fast-growing markets.
- Improve competitive position in North America, China and Japan, in order to grow faster than the market.

The Strategic Management Plan formally came into operation on 1 April 2011. Since its launch in November 2010, the Group has made a number of announcements on key investments underpinning the Plan.

- November 2010 – Announcement of planned new float line in North East Brazil
- December 2010 – Automotive expansion in Mexico
- January 2011 – Reopening of Vietnam VGI float line, dedicated to Solar Energy market.
- February 2011 – Automotive Expansion in South America
- April 2011 – Off-line coating capacity expansion in UK
- May 2011 – Announcement of two new float lines in Vietnam to produce Solar Energy and touch screen products
- September 2011 – Construction work begins on expansion of Automotive glazing capacity and capability in Poland.

Growth of existing products in established markets

Investments have been completed in Pilkington Automotive's plant in Sandomierz, Poland, to provide additional capacity and capability to manufacture the range of value enhancing products required by VMs.

Pilkington Automotive's Specialized Transport business, supplying glazing systems to buses, trucks, trains and ships, continues to grow market share in a sector in which the Group is already a world market leader. A new fully integrated windshield line was launched in Italy. Building work is underway at the Group's new automotive line at Chmielów in Poland.

New products and value-chain growth

The Group stands to benefit from the growing need to conserve energy. Its added value products, such as low-e glass, solar control glass and glass for photovoltaics have the principal purpose of reducing energy consumption in buildings and generating energy from the sun.

In every region of the world in which the Group operates, the need to save energy is a political priority. Buildings account for almost 50 percent of the energy consumed in developed countries.

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Governments are putting increased focus on legislation and policies to improve their energy efficiency. In North America, initiatives such as the environmental building rating system (LEED) run by the US Green Building Council are helping to transform the market for added-value glazing, and this will continue.

Similar opportunities are anticipated in Europe, for example, through the development of an EU-wide Energy Labeling system for windows. In China, legislation is at an earlier stage, but the government has already introduced building regulations to improve the energy efficiency of new buildings.

Over the past year, the Group's Building Products business line has launched a number of energy-efficient products across Europe. These include Pilkington **Suncool™** 70/35, offering a solution to an ever-increasing need to achieve outstanding energy efficiency within buildings without compromising levels of natural daylight. Its very low total heat gain and extremely high light transmission maximize the thermal comfort and aesthetics of a working or living environment.

The Group has also seen excellent growth in the sales of the range of energy-efficient products launched in 2008 under the Pilkington **energiKare™** brand, offering home owners the opportunity to improve the efficiency of their windows by up to 90 percent.

Earlier this year the Group's Automotive business was first to market with Pilkington **Sundym™ Select**, an advanced automotive glazing which allows drivers and passengers to determine how light and heat enters the vehicle cabin, providing the ultimate in customisable glazing.

Glass has an important role to play in the development of the growing Solar Energy sector. The NSG Group is well placed to supply products for all three of the leading technologies, converting power from the sun into clean renewable energy.

Geographic expansion

The Group's first Automotive plant in India is at Vizag in the south east and started production at the end of 2008. The plant is initially concentrating on the production of Aftermarket (AGR) parts for export.

A new low-iron rolled line in Taicang, China started production in June 2008. Originally a 50:50 joint venture between the NSG Group and China Glass Holdings (CGH), this is now wholly owned and operated by the NSG Group.

The integration of the aftermarket businesses of GIMA, a leading supplier of automotive aftermarket glazing, with operations in Hungary and Romania, has further enhanced Pilkington Automotive's European AGR network.

The Pilkington Automotive plants in Guilin, Tianjin and Changchun in China are now integrated into the Group's Automotive global business line. These plants supply both OE and AGR domestically and for export and are well placed to continue growing. Additional investment is planned to increase capacity and product range.

3.3 Building Products overview

Building Products represented 43 percent of the NSG Group's revenue in FY2010/2011. Its operations are organized into six businesses; Europe, Japan, North America, South America, China and South East Asia.

Float glass for the building market is either sold without further processing or processed into products with additional properties. Pilkington-branded products help control energy usage, protect against fire, insulate against noise, provide safety and security, afford decoration and privacy, self-cleanse, are used to build all glass façades and include glass for specialized applications.

Large-scale coating, laminating, and silvering processes are used to make these products. Building Products has float glass manufacturing or processing operations in the following 21 countries; United Kingdom, Germany, Japan, Malaysia, Vietnam, China, Austria, France, Netherlands, Italy, Denmark, Norway, Sweden, Finland, Czech Republic, Poland, Russia, United States, Argentina, Chile and Brazil.

Building Products' main activities include:

- Float manufacturing: 1.0 mm to 25 mm, clear, tinted, extra clear, on-line coated
- Rolled manufacturing
- Semi-finished products: off-line coated, laminated, silvered
- Processing: toughening, insulating glass units, merchenting, fire protection
- Glazing systems: Pilkington **Planar™** (frameless glazing system) Pilkington **Profilit™** profiled glass
- Products for the Technical and Solar Energy sectors

Product range & brands

The Group's products are designed to create the ideal environment in which to live and work. Coated and tinted products, and insulating glass units, help control the flow of energy into and out of buildings.

Solar Control

Solar control is a key issue in terms of energy saving. In hot conditions or for buildings with high internal loads, solar control glass is used to minimize solar heat gain, by rejecting solar radiation, and help control glare. In more temperate conditions it can be used to balance solar control with high levels of natural light. The correct choice of glass can help to reduce the capital outlay, running costs and associated carbon emissions of a building throughout the year.

Given the variety of building designs, climatic conditions and the different levels of exposure to solar

radiation during the year, the glass chosen must be able to protect the inside of the building to ensure maximum comfort, minimize energy consumption, guarantee safety and, not least, provide the optical and aesthetic qualities that satisfy the designer.

The NSG Group is continually innovating and developing products that satisfy the full range of architectural requirements. Pilkington innovative solar control products cover the whole range:

- From the highest performing, off-line coated, solar control and low-emissivity products within the Pilkington **Suncool™** range
- Through on-line environmental control glasses that combine medium performance solar control with low-emissivity such as Pilkington **Eclipse Advantage™** and Pilkington **Solar-E™** ranges
- To medium performance reflective glasses such as Pilkington **SunShade™**, Pilkington **Reflite™** and high performance tints such as Pilkington **Arctic Blue™**
- To low-performance, body-tinted glass in the Pilkington **Optifloat™** Tint range
- And to solar control glass combined with the revolutionary, self-cleaning Pilkington **Activ™**.

In addition to the above ranges, the Pilkington Solar Control range can be used with many other Pilkington solutions, to achieve benefits in safety, functionality and cost efficiency.

Thermal Insulation

Advances in low-e glass technology have made windows an essential contributor to energy conservation and comfort, minimizing heat loss and internal condensation.

Low-e glass reflects energy back into a building, to achieve much lower heat loss than ordinary float glass. Different types of low-e glass allow different amounts of passive solar heat gain, which helps reduce heating requirements and costs, especially in colder months.

The Pilkington low-emissivity range covers all levels of requirements:

- From on-line products such as Pilkington **K Glass™** and Pilkington **Energy Advantage™**
- To extremely low Ug-value off-line solutions in the Pilkington **Optitherm™** range
- Through to Pilkington **Suncool™**, Pilkington **Solar-E™** and Pilkington **Eclipse Advantage™** which are primarily solar control products that also offer low-emissivity properties.

Pilkington **Spacia™** is the world's first commercially-available vacuum glazing, offering the thermal performance of conventional double glazing in only the same thickness as single glass.

Pilkington **Spacia™** has a low overall thickness as well as a good acoustic performance, and is ideal for use in historic buildings, offering replacement windows more in keeping with the original design. It is also available in laminated form for additional safety performance.

Pilkington **Spacia™** may even allow the use of the original frames if these are in good condition. Already successful in Japan, sales are developing worldwide, particularly within historic buildings.

Fire Protection

The Pilkington brand has been at the forefront of fire-resistant glass innovation since 1896, when Pilkington first introduced wired glass. As a leading manufacturer of fire-resistant glass and a pioneer in the market for transparent fire protection, the NSG Group sets particularly high standards in level and consistency of performance and visual quality.

The Group offers four product lines and technologies to protect people and property against fire:

- Pilkington **Pyroshield™ 2** (wired glass for integrity-only fire protection),
- Pilkington **Pyroclear®** (clear monolithic fire-resistant and safety glass for basic integrity)
- Pilkington **Pyrodur®** (clear laminated fire-resistant and safety glass for integrity and reduced heat radiation)
- Pilkington **Pyrostop®** (clear multi-laminated fully insulating fire-resistant and safety glass for integrity and insulation).

The range of transparent laminated products is the global market leader in high performance fire-resistant glazing. The products are laminated with special transparent intumescent interlayers, which when exposed to fire, foams up to form a thick, resilient, insulating shield that absorbs the energy of the blaze. The products can be combined with other products from the Pilkington range to offer additional properties if required.

The products in that range provide not only protection against flames and smoke, but also a high degree of protection against the heat of a fire, by all transfer mechanisms (i.e. conduction, convection, and radiation). Pilkington **Pyrostop®** and Pilkington **Pyrodur®** have been tested in more fire doors, fire protection framing and façade systems than any other fire-resistant glass products, covering vertical, horizontal and inclined glazed situations.

As an example of the high level capability of the intumescent interlayer system, the tested range of approvals includes many high performance constructions used in sensitive buildings and areas such as schools, hospitals, commercial and retail buildings, and airports.

The emphasis of the Pilkington intumescent technology is on fitness for purpose, reliability and

repeatability of performance. Today, Pilkington fire-resistant glasses are well respected and used in various building, marine, and rail transport applications all over the world.

Noise Control

With increasing traffic on the road, rail and in the air, noise insulation has become a very important issue. No longer a luxury, it is essential that noise reduction is considered in the specification of the glazing. With regard to employment law, comfort and medical necessity, noise insulation in building construction is an undisputed requirement to decrease stress- and noise-related illnesses.

Pilkington **Optiphon™** is the ideal choice of glass in situations where there is excess noise from road, rail or air traffic, or various other sources, for example factories or nightclubs. By using a special PVB (polyvinylbutyral) interlayer, Pilkington **Optiphon™** is a high quality acoustic laminated glass that offers excellent noise reduction without compromising on light transmittance or impact performance. The desired acoustic performance can be achieved through combining various thicknesses of glass with a PVB interlayer. With a wide range of product combinations, Pilkington **Optiphon™** offers the opportunity to achieve specific noise reduction requirements.

Safety and Security

Innovations in the development of safety and security glasses have opened up new avenues of design, allowing people to be protected from personal injury and in the most extreme cases, buildings to be protected from various forms of attack, without compromising levels of natural light and visibility.

The term "safety" is applied to glazing used to reduce the risk of accident by impact, fracture, shattering, or in a fire. The term "security" is applied to glazing, which in addition to "safety", is able to withstand deliberate attacks such as physical, armed or blast. Specialist glass of this type must be combined with high performance glazing and framing systems, capable of offering the necessary resistance to the severe loads that could be imposed.

In parallel, stringent safety legislation has been implemented stipulating the critical areas where safety glazing must be installed to comply with required safe practice.

The Group has developed a wide range of sophisticated glasses to meet these increasing demands for protection of both people and property.

Pilkington Toughened Safety Glass is a glass that has been subjected to a heating and cooling treatment whereby high compressive stresses are set up at the surfaces with balancing tensile stresses in the centre. The high compressive surface stresses give the Pilkington Toughened Glass its increased strength (up to five times stronger than ordinary glass of the same thickness).

Pilkington **Optilam™** is a laminated glass, produced by combining two or more sheets of float glass with one or more PVB interlayers. The interlayers ensure the integrity of the glass by holding the broken pieces in place should any damage occur. In fact, glass fragments adhere strongly to the interlayer, while the resistant cushioning effect dissipates the energy.

Self-Cleaning glass

Pilkington **Activ™** Clear is the world's first dual-action self-cleaning glass. Its unique coating uses the forces of nature to help keep the glass clear of dirt, giving not only the practical benefit of less cleaning, but also clearer, better looking windows.

It works in two ways: first it uses daylight to break down organic dirt and then it uses rain to wash any loosened dirt away. Pilkington **Activ™** Clear also dries off faster leaving the glass cleaner and with reduced streaks, which gives beautiful clear views and makes it ideal for various applications, from building façades to conservatory windows.

Products in the Pilkington **Activ™** range are on-line coated; they can therefore be toughened, processed and handled using standard techniques. The Pilkington **Activ™** Solar Control range combines the benefits of self-cleaning with varying degrees of solar control performance to offer the ultimate range of solar control solutions for hard-to-reach places that are difficult to clean.

Pilkington **Activ Suncool™** is a range of glass products with a coating on both surfaces; it combines self-cleaning, thermal insulation and the highest solar control performance. Pilkington **Activ™** Neutral (dual-coated solar control and self-cleaning glass) and Pilkington **Activ™** Blue (coated body-tinted solar control and self-cleaning glass) are perfect for use in conservatories and glass roof structures.

The Pilkington **Activ™** products can be further enhanced when combined with other Pilkington products to offer additional advantages such as thermal control, noise control or safety.

Decoration

As well as offering functional benefits, glass is also used to enhance the appearance of the environment. The Pilkington range of decorative glass turns it from a basic construction material into a means of adding style and elegance. By incorporating decorative glass, you can add privacy and meet any requirements, aesthetic or practical.

Pilkington Texture (Patterned) Glass offers privacy and style throughout the home.

Pilkington Spandrel Glass is a toughened safety glass mostly used in non-vision area of the façade. The extensive range of products that has been developed for use as spandrel panel includes: Pilkington Spandrel Glass Enameled, Pilkington Spandrel Glass Silicon and Pilkington Spandrel Glass Coated.

Pilkington **Optimirror™** is a range of high specification mirror products, produced using the latest environmentally-friendly processes and materials.

The products are available on clear, (Pilkington **Optimirror™**), bronze (Pilkington **Optimirror™** Bronze) and low-iron substrates (Pilkington **Optimirror™** OW), offering increased light reflection. Pilkington **Optimirror™** Protect protects against possible injury resulting from breakage thanks to the additional safety film backing that it contains.

Pilkington **Optifloat™** Opal is an acid-etched glass which creates an attractive finish for windows, partition walls, glass doors, furniture, shelving, wall cladding and many more internal and external applications. The glass provides all the diffused natural light of a translucent glass, but with none of the drawbacks.

Glass Systems

Pilkington **Planar™** is a structural glazing system, allowing architects immense flexibility in the appearance of façades, whilst incorporating all of the functionality required from windows in today's buildings. Pilkington **Planar™** can incorporate most Pilkington glass types - which includes the range of solar control products, low-emissivity glass, screen printed glass and Pilkington **Activ™** self-cleaning glass.

Another popular product, Pilkington **Profilit™** is a range of alkali cast glasses in U-shape, produced using the machine rolling process. It is translucent, but not transparent, with a patterned surface on the outside. This highly durable product allows light to enter buildings whilst presenting a translucent external appearance. A wide range of fitting options provides considerable flexibility.

Pilkington **Profilit™** is available in different colors, patterns and types of coating, offering different functions including thermal insulation, solar control, noise control or safety. The product can be single glazed or double glazed, either vertically or horizontally.

Special Applications

Glass for Special Applications provides unique characteristics used in both building and non-building applications:

Pilkington **Optiwhite™** is an extra-clear, low-iron float glass; it is practically colorless, and the green cast inherent to other glasses is not present. It is therefore ideal for use where glass edges are visible or where a neutral color is desired. As its light transmission is much higher than clear float glass, it is perfect for applications where transparency and purity of color are desired.

Pilkington **OptiView™** is a monolithic glass with a low reflection coating on one surface, which reduces visible light reflectance and allows more visible light to pass through, when compared to clear float glass. Pilkington **OptiView™** Protect is a laminated glass with low reflection coatings on both outer surfaces, Pilkington **OptiView™** Protect is a laminated glass with anti-reflective coatings on both outer surfaces, which reduces interior and exterior visible light reflectance to around 2 percent, and offer improved safety, enhanced security, durability and acoustic properties. Furthermore, it provides protection from UV radiation (UVA and UVB) by blocking over 99 percent of UV transmittance, helping to reduce fading of the contents and interiors of a building.

Pilkington **Microfloat™** and Pilkington **Microwhite™** are extremely thin, high-grade float glass manufactured to precise standards. Pilkington **Microfloat™** has traditionally been used for the production of microscope slides, cosmetic mirrors, chromatographic plates, LCD photo masks, automotive and technical glass, PC display screens and tablet PCs. Its low-iron composition version, Pilkington **Microwhite™**, is well suited for many applications and is also ideal for use in solar concentrator applications.

Pilkington **Mirropane™** is a coated glass developed for use as a one-way mirror where total clear vision is required and specific lighting conditions can be achieved. Under specified lighting conditions it offers an effective means of providing undetected surveillance and high quality one-way vision to achieve complete privacy.

Solar Energy

Solar energy panels offer alternative solutions for a range of energy requirements, from small scale domestic applications to large scale solar power stations, from cloudy northern rooftops to hot sunny deserts. Glass is an integral and important element of these solar panels.

The NSG Group's wide range of high quality products are used in the three leading solar technologies aimed at converting solar energy into electricity: thin film photovoltaics, crystalline silicon photovoltaics and concentrated solar power applications. In addition to the generation of electricity, the Group's glass products are also used in solar applications that generate hot water.

NSG **TEC™** is a group of products, including a comprehensive range of TCO (Transparent Conductive Oxide) coated glass, optimized to suit a variety of thin films photovoltaic technologies, with different haze and conductivity levels. Each of the products within the range is targeted at a particular thin film photovoltaic technology and can be optimized to meet individual customer requirements.

Pilkington **Sunplus™** is a high performance, low-iron glass designed to maximize solar energy collection through very high light and solar transmission. The high solar energy transmission of Pilkington **Sunplus™** makes it an ideal choice for Crystalline PV photovoltaic solar cells.

Pilkington **Optiwhite™** is a range of extra-clear low-iron float glass with very high solar transmittance for improved solar energy conversion and consistent performance. The products are suitable for use in photovoltaic modules, solar thermal collectors and solar mirrors. The Pilkington **Optiwhite™** range includes the standard and well established low-iron Pilkington **Optiwhite™** and Pilkington **Optiwhite™** S, which was developed specifically for the solar industry and offers even greater solar transmission. Pilkington **Microwhite™** is Pilkington **Optiwhite™** in its extremely thin version (glass thicknesses down to 1.0 mm).

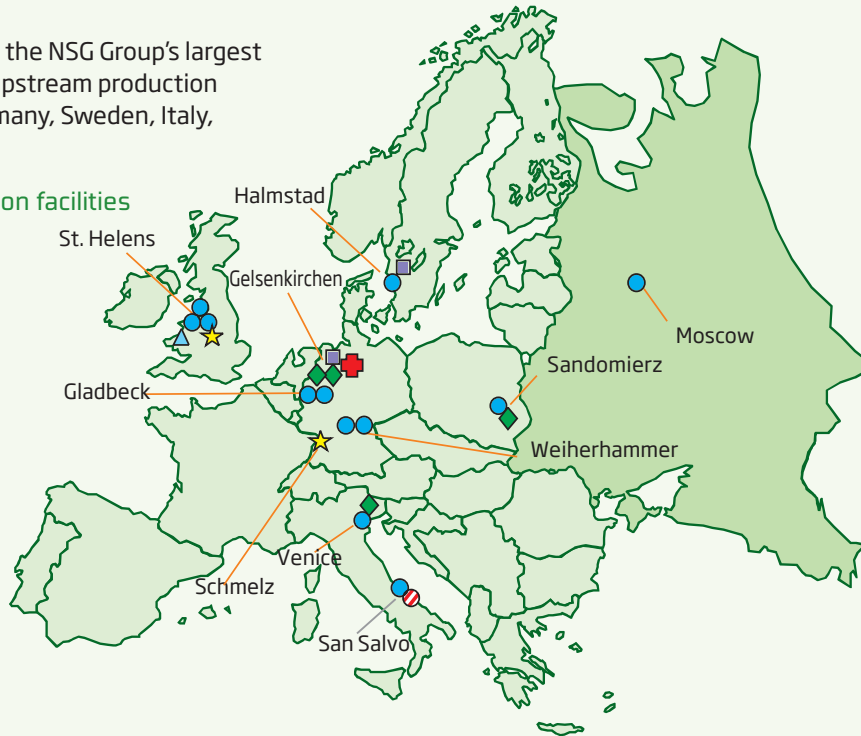
Building Products businesses

Building Products Europe

Building Products Europe is the NSG Group's largest single business. The main upstream production facilities are in the UK, Germany, Sweden, Italy, Poland and Russia.

Europe - primary production facilities

- Float
- ★ Rolled
- ◆ Laminating
- Coating
- ▲ Silvering
- ⊕ Fire Protection
- ⊘ JV Float



Building Products Europe is the NSG Group's largest single business.

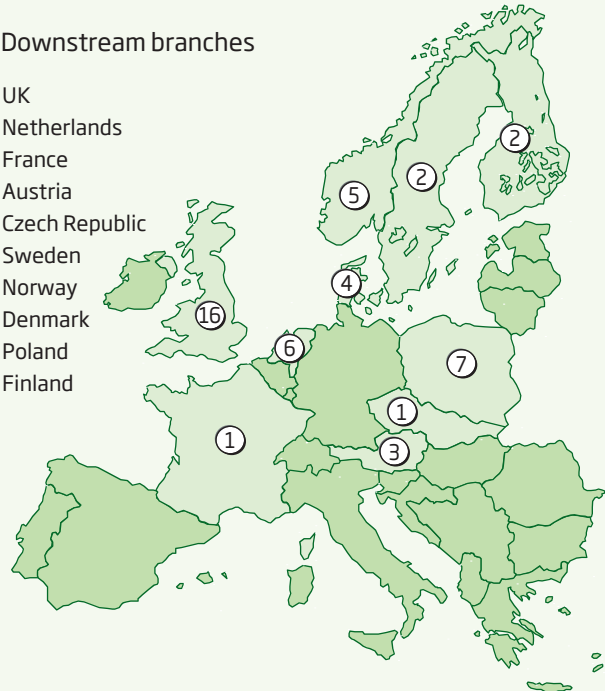
The downstream part of the business includes glass processing and wholesaling operations, serving the European market through a network of forty-seven branches across ten countries (Austria, Czech Republic, Denmark, Finland, France, Netherlands, Norway, Poland, Sweden and the United Kingdom). The extensive range of products and services includes merchandising, the manufacture of safety glass, and the complete range of Pilkington **Insulight™** insulating glass units. Special Products such as Pilkington **Planar™** and Pilkington **Plateau™** are also produced by branches of the European downstream business.

The downstream business has developed over the last ten years into a significant contributor to European profits, through its culture of service to customers, and continuous improvement of productivity and safety for employees.

Europe: Distribution of "Downstream" operations

Downstream branches

- UK
- Netherlands
- France
- Austria
- Czech Republic
- Sweden
- Norway
- Denmark
- Poland
- Finland



The European Downstream business serves the market through a network of 47 branches across 10 countries.

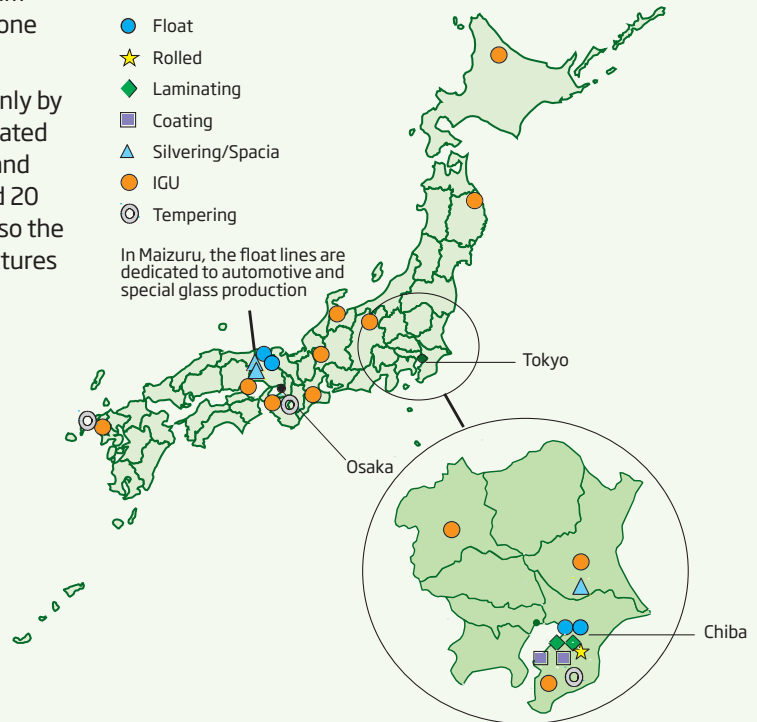
Building Products Japan

Building Products Japan has its main Upstream production site in Chiba (two float lines and one rolled line).

The downstream business, represented mainly by off-line coating, insulating glass units, laminated glass, tempered glass, fire protection glass and vacuum glazing production, is spread around 20 different sites across the country. Japan is also the only location where the NSG Group manufactures Pilkington **Spacia™** - the world's first commercialized vacuum glazing product.

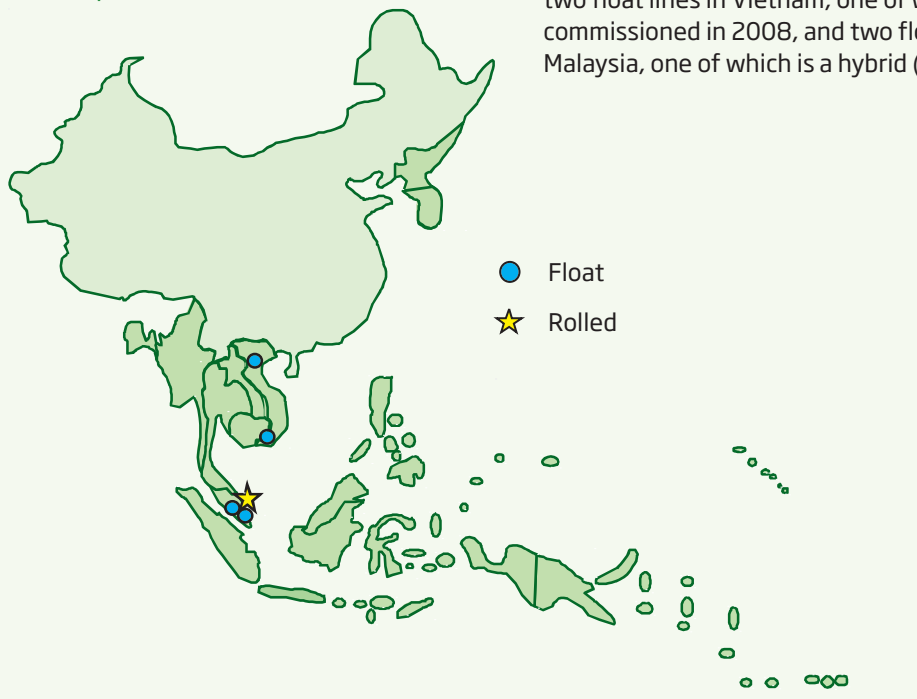
With six regional sales offices, the business offers a full range of products and services to its customers.

Japan - production facilities



Building Products South East Asia

South East Asia - production facilities



Building Products South East Asia is represented by two float lines in Vietnam, one of which was commissioned in 2008, and two float lines in Malaysia, one of which is a hybrid (float/rolled) line.

Building Products China

The NSG Group has minority interests in two major glass manufacturing businesses in China - SYP (two float lines, one rolled line and extensive glass processing) and China Glass Holdings (13 float lines).

SYP's two Shanghai float lines were closed in December 2008 and one was replaced in nearby Changshu .

In addition, NSG itself operates a float in Changshu, in a 50:50 JV with SYP. Advanced on-line coating was installed on the line in 2009, which is enabling it to respond to the rapidly growing, regulation-driven market for value-added low-e glass.

This technology is now being upgraded for the manufacture of NSG **TEC™** products, with shipments from Changshu expected to begin in January 2012.

NSG will have another 50:50 JV float line with advanced on-line coating in operation in 2012, located in Tianjin.

The Group operates a further rolled line which produces low-iron cover plates for the Solar Energy sector. The line has anti-reflective coating capability to further enhance the performance of the glass.

China - production facilities



Building Products North America

Building Products North America manufactures and distributes products for the architectural/ commercial market (exterior and interior), residential market, specialty glass market and fire-rated glass market for a diverse range of applications.

The business has four float lines across the USA, in California (Lathrop), Illinois (Ottawa), and two in North Carolina (Laurinburg), three of which have on-line coating capability.

North America - production facilities



In Rossford (Ohio) two floats are dedicated to Automotive.

Building Products South America

The Group's strategy in South America has for many years concentrated around operating jointly-owned float facilities with Saint-Gobain, a relationship furthered in 2004 with the completion of the fourth joint venture line in Barra Velha, Brazil. This partnership is set to continue with the joint commissioning of a fifth facility in Brazil.

There is only one other float glass manufacturer in South America, besides the NSG Group and Saint-Gobain, namely Guardian with one line in Venezuela and two in Brazil. NSG Group and Saint-Gobain together operate four lines in Brazil and NSG Group operates one in Argentina and one in Chile. The Group also has warehousing activities in Colombia, Ecuador, Bolivia, Paraguay, Uruguay and Peru.

The South American region traditionally has a higher growth rate than the northern hemisphere although it is occasionally disrupted by economic instability in particular countries.

NSG Group and Saint-Gobain together operate four lines in Brazil and the NSG Group operates one in Argentina and one in Chile.

South America - production facilities



3.4 Automotive overview

The Automotive business of the NSG Group operates under the Pilkington Automotive name and is one of the world's largest suppliers of automotive glazing products.

In serving this market, Pilkington Automotive operates a global key account network, matched to the individual VM's own organizational requirements. Within the automotive glazing industry, Pilkington led the way in globalizing its account management and presenting a single face to the customer.

Pilkington Automotive operates automotive glass fabrication plants and satellite facilities throughout Europe, Japan, NAFTA, South America, China, Malaysia and India; 31 locations in total in 16 different countries.

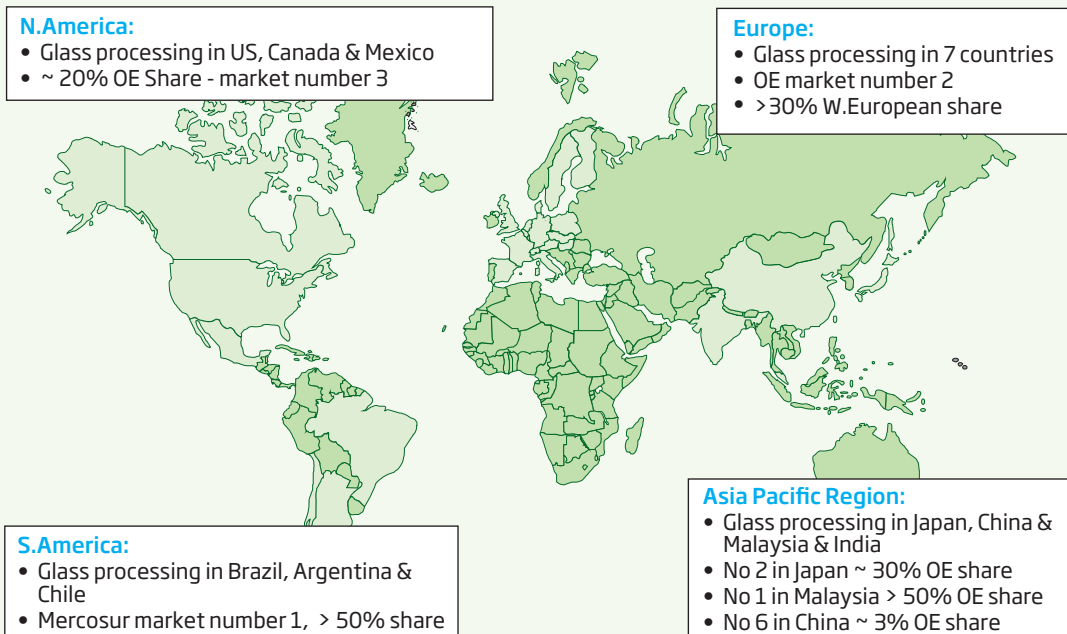
Through restructuring of its established facilities and the establishment of new ones in the fast developing markets, Pilkington Automotive continues to match its asset base to regional demand, both in terms of volume and, equally as important, technical capability and service.

The Pilkington Automotive global business line was formed in the mid-1990s, in recognition of the automotive industry's own increasing globalization. The business is now fully integrated and managed on a global basis, subsuming all of the former Pilkington and NSG Automotive operations worldwide.

This new organization enables optimization of the NSG Group's global asset base and its exploitation of available synergies across its business segments.

As well as its major OE businesses within each region, Pilkington Automotive also supplies replacement glazings into the independent aftermarket. Pilkington Automotive has developed extensive AGR networks throughout NAFTA (121 wholesale locations) and both Western and Eastern Europe (86 service facilities). It also serves the aftermarkets in Japan, South America, China and South East Asia.

Pilkington Automotive global presence



Pilkington Automotive's markets

Original Equipment (OE)

The vast majority of Pilkington Automotive's OE production is focused on the volume light vehicle industry, serving all of the world's major VMs.

Of all such vehicles built in the world last year, more than one in three contained glazing manufactured by Pilkington Automotive businesses. Additionally, Pilkington Automotive globally coordinates its approach to the specialist/niche vehicle makers and roof-system manufacturers.

Aftermarket (AGR)

Pilkington Automotive aftermarket products can reach the end user by one of two main routes; the VMs' own dealer networks or independent AGR distribution chains, including Pilkington Automotive's own, supplying the retail fitter.

Pilkington Automotive itself has well developed aftermarket distribution and wholesale networks throughout Europe and North America with estimated market shares around 20 percent. It is also well established in serving the aftermarkets in Japan, South America and South East Asia.

Specialized Transport

Pilkington Automotive provides high quality glazing solutions and value-added products to the Original Equipment manufacturers of specialized transport and utility vehicles. These include buses and coaches

trucks, trams and metro systems, locomotives, train , carriages, special cars and vans, recreational vehicles, tractors and combine harvesters, construction vehicles as well as ships and pleasure craft (Pilkington Marine). Pilkington Automotive's customers are recognized as world-leading manufacturers, with many operating on a global basis.

Pilkington Automotive products and services

Pilkington Automotive makes a wide range of automotive glazings for new vehicles and for replacement markets, offering full systems capability to customers, from initial design to final product. Pilkington Automotive products include solar control glass for passenger comfort, glass heating systems to control condensation and icing, security glazing, and glazing systems, including encapsulations, extrusions, and components such as rain sensors, hinges and clips, added after basic manufacturing.

The Group aims to provide a full range of glazing solutions on a global basis to its automotive customers, drawing heavily on its advanced technology, continuous improvement and standardization activities.

Just as in buildings, glass today is an integral part of a vehicle's body and fulfils many functions. Design trends point to still greater usage of glass in the future; tighter tolerances, yet deeper and more complex curves.

The glass manufacturer must be able to control very closely the pattern of temperatures in the glass throughout the shaping process if overall shape, optical quality and stress patterns are to be achieved consistently.

Utilizing its global R&D and global account management structure, Pilkington Automotive's market-focused approach to the development of products and services ensures that it delivers the glazing solutions its customers want, in a timely fashion to the appropriate regions.

Design facilities

The growing complexity of glazings has increased the need for integrating simulation within the shaping processes. Pilkington Automotive is recognized as a leader in the development and use of computer simulation for advanced glazing technology, providing customers with the best possible glazing solutions with which to achieve their styling intent.

Pilkington Automotive's computer simulation centre team predicts the optical properties of a particular shape of windshield, how closely any of the bending processes will achieve the required shape and tolerances, and how difficult manufacturing challenges may be overcome. This virtual reality product development approach reduces both tooling and manufacturing costs and dramatically reduces the time between design and manufacture. Pilkington Automotive simulation techniques have been empirically tested and shown to give excellent correlation to actual manufacturing processes and continuous benchmarking ensures ongoing improvements.

Pilkington Automotive has wide-ranging experience in design integration, where Pilkington engineers work side by side with customers to achieve the optimum design for function and manufacture. Involvement of Pilkington Automotive personnel at the very earliest stage in the design of the vehicle helps the customer identify potential manufacturing or design problems, thereby avoiding expensive redesign at a later stage. It also ensures that glasses meet legislative requirements for optics and enables Pilkington Automotive to recommend benchmark styling modifications leading to more cost-effective products and other glazing systems (e.g. encapsulation and extrusion) design. Data is transferred between Pilkington Automotive and its customers electronically, avoiding the need for drawings and physical fixtures in the design of new glazings.

Glass shaping

Numerous market factors affect glazing design and performance, including cost reduction, tighter tolerances, high optical quality, design complexity and weight considerations. To meet these stringent market requirements, Pilkington Automotive continues to develop and invest in leading-edge glass shaping and fabricating technology. Changes in styling and the need for lighter, thinner glazings to reduce weight are pushing manufacturing processes. Pilkington Automotive maintains an extensive program of process development to keep abreast of the latest design trends. For instance, new styling requirements for windshields that extend into the roof of the vehicle, or wrap around into the side of the vehicle, demand significant extension of both gravity sag and press bending technologies. Pilkington Automotive has developed Advanced Sag and Press Bending processes to secure its position as a supplier of the most advanced products.

In support of its manufacturing processes, Pilkington Automotive is continually developing powerful new on-line inspection techniques, capable of analyzing every aspect curvature, optical distortion, edge quality and scratches as the component takes shape. These systems will provide real time feedback for process control to increase yields and so reduce costs.

Variable light transmission

Pilkington Automotive has launched the world's most advanced automotive glazing product available to the mainstream market. Pilkington **Sundym™ Select** offers a range of benefits: The product allows drivers and passengers to decide how much light and heat enters the vehicle cabin, providing the ultimate in a customizable glazing feature. Used as a roof glazing, it can also remove the need for a mechanical blind system, thereby reducing weight and increasing the vehicle's headroom.

Glazing Systems

The task of the glazing supplier does not end when the glass is shaped. Pilkington Automotive is a world leader in the design and manufacture of a variety of glazing systems, each designed to simplify the glazing installation process. As well as the efficiencies provided at the vehicle assembly plant, these modular product solutions are also viewed by the VMs as a practical way of enhancing both a vehicle's styling and aerodynamics.

Encapsulation, or molding, provides a modular glass assembly with a multifunctional gasket around the rim of the glass, utilizing injection-molding technology. This gasket can provide many features from a single molding process, including an aesthetic finish to the glazing, water management, integrated attachment pins or clips, and mounting brackets or hinges.

Alternative sealing systems involve the use of a robotic extrusion process to apply a seal or attachment mechanism to the periphery of the glass.

Glazing systems also encompasses the 'assembly' activity where various hardware attachments, designed to locate correctly the glass within the vehicle, are fixed to the glass, either mechanically or by the use of adhesive technology.

With decades of glazing systems experience behind it, Pilkington Automotive is a market leader in all of these technologies, in terms of both product and process development and global market share.

Solar control glazing

The last decade has seen significant improvements in the design and application of solar control glazings in vehicles. The major drivers are passenger comfort, minimizing the degrading effects of the sun's radiation on interior trims and fabrics, and improving fuel consumption by lowering the load on the vehicle's air-conditioning unit. Additionally, vehicle styling is impacted by the choice of solar control glazing, from dark tints in the rear of the vehicle, to the differentiated color of infrared reflective windshields.

Solar radiation is partly reflected, partly transmitted and partly absorbed by glazing, the degree of each depending on the glazing fitted. Body-tinted glasses can selectively absorb the sun's energy, whilst glazings with specially designed coatings can be used to reflect solar radiation.

Absorbing solar control

Pilkington Automotive has long been a market leader in body-tinted glass compositions. **Optikool™**, **EZKOOL®** and UV Cut are green, optimized solar-absorbing glasses, providing significant improvement to occupant comfort. The products, designed for the European, North American and Japanese markets

respectively, reduce the heat entering through a vehicle's glazed area by approximately 20 percent when compared to a car equipped with standard tinted glass. Pilkington Automotive is also a market leader in the development of dark tinted automotive glazings, and today produces two such suites of glasses, both of which provide significant benefits to solar control, privacy and overall vehicle styling.

Due to vehicle safety legislation, requiring adequate light to provide clear driver vision, use of these dark tinted glazings is restricted to rear passenger compartments and to roof glazings.

Pilkington Automotive is a market leader in the development of dark tinted automotive glasses.

The **Galaxsee™** glass suite is a major player in the privacy glazing segment. Originally developed for the North American market, it now finds global applications. This grey glass has a low light transmission (13-26 percent depending on thickness selection) and an even lower transmitted energy value. It reduces the transmitted heat to the interior of the vehicle by approximately 65 percent in comparison to an optimized green glass used in the front of the vehicle. It also prevents more than 95 percent of ultraviolet radiation from entering the passenger compartment. Consequently, this glass is increasingly the choice for 'dark tail' SUVs and MPVs, in addition to being suitable for roof glazing applications.

Pilkington **Sundym™** and the Legart range form a suite of neutral green privacy glasses that blends with the green front door glass to allow both a design choice and an improvement to solar loading.

Pilkington **Sundym™** glass has a light transmission in the range 26-45 percent over a 3-5 mm glass thickness range. In a vehicle equipped with Pilkington **Sundym™**, the heat entering the rear of the vehicle is reduced by 45 percent when compared to that at the front of the car.

The market continues to adopt these glasses due to the valuable combination of both physical and aesthetic benefits.

Reflective solar control

Pilkington Automotive possesses the technology and capability to deliver a coated windshield product that reflects more than 30 percent of the sun's energy (more than five times that of a standard glass). This particularly benefits the new generation of vehicles that are commonly designed with larger glass areas.

Significantly, the Pilkington coating technique is advantageous in the pursuit of improved vehicle styling, as it can deliver highly complex shapes with exceptional optical quality.

Pilkington Automotive produces a windshield product that reflects more than 30 percent of the sun's energy (more than five times that of a standard glass).

Pilkington Automotive also offers a solar reflective product, Pilkington **Siglasol™** utilizing infra red reflecting film within the laminate. Reflective glazings have now been successfully integrated into large area rooflights. This application is the most significant for solar control in a vehicle, as the sun's radiation is minimized, irrespective of the vehicle's direction of travel.

Laminated sideglazings

For over 25 years, the standard glazing constructions for automotive vehicles have been laminated glass for the windshield and toughened glass for the side and rear glazings.

The trend to fit laminated sidelights started in Europe, but adoption in North America is now very strong and there is also interest with Japanese vehicle manufacturers launching models fitted with side laminates. The move to laminated side and rear glazings represents a turning point for advanced vehicle design opportunities and is more significant than the volume change from toughened to laminated windshields in 1970.

Extensive consumer market research has confirmed that consumers are very interested in laminated sidelights and prepared to pay a premium to have them fitted to the vehicle. The consumer sees benefits in two areas:

Security

- Personal security
- Reduction in theft from cars

Comfort

- Solar control improvement
- Reduction in extraneous noise
- Greater than 95 percent reduction in UV entering the vehicle through the side glazings

Laminated sidelights have a similar construction to laminated windshields, namely a plastic interlayer sandwiched between two glass plies. In order to meet door slam tests, both plies need to be semi-toughened to give additional strength to the glazing. Currently most products are 2.1/0.76/2.1 mm, 1.8/0.76/1.8 mm and 1.6/0.76/1.6 mm construction. The trend to lighter weight glazing means that an overall 4 mm make up is becoming critical as laminates are adopted on lower segment vehicles. Pilkington Automotive researchers

have made it possible to supply high quality 4 mm laminated sidelights in simple and complex geometry to tight tolerances.

Besides its intrinsic benefits identified above, laminated glazing also offers an opportunity to create advanced glazings with additional features, such as coatings or wire heating for de-misting, or modified interlayers (e.g. solar control, colors, acoustic enhancement).

The additional cost of laminated side glazings is offset by the above opportunities which can enable the car manufacturer to customize the vehicle and make it more attractive and desirable to the car buyer. Today's vehicle designers expect the glazing to perform as more than merely a window. They want added functionality.

Integrated antennas

With the ever-increasing demands of global communication systems, Pilkington Automotive can design and manufacture fully integrated antenna systems either on the glass surface, or inside the glazing construction. This approach allows the VM to move away from traditional rod-based antennas, which not only improves the styling and aesthetic appeal of the vehicle but also removes the threat of vandalism. The use of on-glass antennas is firmly established in Japan, a known pacesetter for electronic solutions, and is now increasing in Europe and North America. Considerable expertise exists inside Pilkington Automotive to take advantage of this growing trend.

Instrument display

Head Up Display (HUD) systems have long been used in military aircraft to project information into the pilot's field of vision. Pilkington Automotive has successfully adapted this technology so that it can be used in road vehicles at a cost acceptable to the market. Interest in HUD technology is continually growing as people demand ever more functionality in their vehicles.

Pilkington Automotive's advanced press bend windshields offer absolute 'state of the art' optical surfaces for the HUD systems to display the image on. The excellent full surface control properties of the press bend windshields are perfectly aligned to the tight tolerance requirements to ensure that 'ghost images' are not seen by the end users. Facilities to manufacture these types of windshields exist in Europe, North America and Asia.

Water management

Pilkington Automotive's **Hotscreen™** product incorporates fine wires that are capable of de-icing a frozen screen at -5°C inside two minutes. A recent innovation allows the full area of the screen to be de-iced within this timescale. Further customer benefits are achieved if this type of technology is employed where the wipers rest on the windshield.

Pilkington Automotive has also developed a full area coated heated windshield that provides both de-ice and anti-mist properties. As power levels increase in vehicles, this will provide an elegant way to electrically heat windshields that have an infrared reflective coating applied directly to the glass. This heating functionality is in addition to the benefits of optimized solar control and high shape complexity that are already achieved with Pilkington Automotive coating technology.

Pilkington Automotive has also developed a patented sensor that detects moisture on the windshield and automatically activates the windshield wipers. This rain sensor, attached to the interior of the windshield, detects moisture by using infrared light emitting diodes. This technology is licensed in the market place and is being increasingly adopted on new models.

Another technology that improves driver visibility is a 'hydrophobic' coating, which is applied to the outside glass surface and significantly improves water droplet flow from the vision area. Hydrophobic products are used extensively in Japan, with significant adoption in Europe and market interest in North America.

Full service supply

Driven by the industry's need for increased design efficiency and reduced time to market, Pilkington Automotive has developed a world class, full service supply capability. For the majority of its OE customers, Pilkington Automotive provides design expertise which then leads to product sequencing and 'just in time' delivery to the VM's assembly line.

AGR market offerings

Whilst all of the glazing products offered by Pilkington Automotive are initially seen in the OE market, the benefit of increasingly complex glazing installations is also felt in the aftermarket. In addition to supplying replacement glazings to the aftermarket, Pilkington Automotive also sells the tools and accessories used by windshield fitters, thereby supplying them with all the equipment required for a re-glazing job.

4. Sustainability

Glass has a unique role to play in promoting sustainability, reducing greenhouse gas emissions and mitigating the effects of climate change. The 'energy balance' between manufacture of high-performance glazing products and their use means that the energy used and CO₂ emitted in manufacture are quickly paid back through the lifetime of the products. The energy involved in glass-making should therefore be seen as an investment in future energy saving.

The NSG Group is fully committed to sustainability. The Group's policies underline the unique contribution its products can make to addressing climate change and the challenges the Group faces in improving its own energy usage and resource management. The Group's product range and R&D efforts are geared to addressing the challenges of a low-carbon world.

Glass in buildings

products can make an important contribution to combating climate change. Improving the energy efficiency of buildings brings other benefits too. Buildings are more comfortable and cheaper to run for the owner and occupier. And from a social point of view, national economies and energy security will improve when energy-importing countries become less dependent on increasingly expensive supplies from other parts of the world.

CO₂ emissions and low-e double glazing

The European glazing trade association, Glass for Europe, of which the NSG Group is a member, published in 2005 a study into the CO₂ savings potential of replacing ordinary single or double glazing with low-e glass. It showed that CO₂ emissions from buildings, which amount to 765 million tonnes of CO₂ per year in the EU, could be cut by 140 million tonnes if the current glazing was replaced by low-e double glazing.

CO₂ emissions from buildings, in the EU could be cut by 140 million tonnes if current glazing was replaced by low-e double glazing.

Even taking into account the 4.6 million tonnes of CO₂ released per year by the building glass industry in its production processes to manufacture the additional glass required, the replacement of obsolete glass in old buildings and specification of energy-efficient glass in all new buildings would result in a huge net benefit.

CO₂ emissions and solar control glazing

In regions where the ambient temperature is often uncomfortably hot, the increasing tendency is to install air conditioning and that, of course, brings with it an energy and carbon burden. Glass for Europe has recently published a report, 'Impact of Solar Control Glazing on Energy and CO₂ Savings in Europe', which quantifies the potential CO₂ savings in the year 2020 through the installation of solar control glass in air-conditioned buildings. The study shows that installing solar control glass versus air conditioning under the current growth scenario would produce annual savings of around 1.1 million tonnes of CO₂ by 2020. If air conditioning use in Europe were to approach the level of usage in North America, annual savings would be closer to 7 million tonnes.

Sustainability in buildings

Glass is used extensively in most buildings, both for exterior and interior use; as a construction material, for functionality, for decoration and for interior fittings. Around the world, policy-makers have begun to realize how important the quality of buildings is in relation to the quality of the environment and to the overall quality of people's lives.

Policy and legislative activity addressing the building sector, including the glass products that are used in buildings, is increasing worldwide. The Group's products play a vital role in improving energy efficiency and reducing CO₂ emissions. But they also offer other advanced functionality, protecting against fire, insulating against noise, offering safety and security, privacy, decoration and even self-cleaning properties.

Glass is used extensively in most buildings, both for exterior and interior use; as a construction material, for functionality, for decoration and for interior fittings. Around the world, policy-makers have begun to realize how important the quality of buildings is in relation to the quality of the environment and to the overall quality of people's lives.

Energy efficiency in buildings

In every region of the world in which the Group operates, the need to save energy is a political priority. Buildings account for almost 50 percent of the energy consumed in developed countries. Governments are putting increased focus on legislation and policies to improve their energy efficiency.

Buildings account for almost 50 percent of the energy consumed in developed countries.

In North America, initiatives such as the environmental building rating system (LEED) run by the US Green Building Council are helping to transform the market for added-value glazing, and this will continue.

Similar opportunities are anticipated in Europe, for example, through the development of an EU-wide Energy Labeling system for windows. In China, legislation is at an earlier stage, but the government has already introduced building regulations to improve the energy efficiency of new buildings.

Thermal insulation - keeping heat in buildings

In cold weather, low emissivity (low-e) products reflect heat back into the building. Pilkington thermal insulation products combine unrivalled thermal insulation with high light transmittance and lower reflectance for a more neutral appearance.

The Group's Pilkington **Spacia™** product was developed in Japan and was the world's first vacuum glazing commercially available, offering the thermal performance of conventional double glazing in the same thickness as single glass. Sales for this product are developing worldwide, particularly for use in historic buildings.

For the residential market, the Group has developed products combining thermal insulation and passive solar gain, helping domestic window companies meet homeowner demand for more energy-efficient windows.

In warm weather, Pilkington solar control products dramatically reduce or reflect the sun's heat transmitted through the glass, while transmitting the majority of the light, minimizing the need for air conditioning. Solar control is a key issue in terms of energy saving. In hot conditions or for buildings with high internal heat loads, solar control glass is used to minimize solar heat gain, by rejecting solar radiation and helping to control glare.

In temperate conditions, it can be used to balance solar control with high levels of natural light. The correct choice of glass can help to reduce the capital outlay, running costs and associated carbon emissions of a building throughout the year.

Glass and solar energy

Glass has a key role in attempts to find cheaper and more efficient ways of generating power from the sun. The Group's products support the three leading solar energy technologies; thin film and crystalline solar modules and concentrated solar power applications.

Glass is an integral and important element of solar modules, used to convert solar energy into electricity. Increasingly, electrically conductive glass is used in photovoltaic modules as the front contact of the solar cell, to form a system which generates a direct electrical current. Where the power feeds into a grid, it is first converted into alternating current.

The United States and the European Union in particular, are encouraging the production of renewable energy and in December 2008 the EU published the Renewable Energy Directive. Carbon-trading schemes encourage CO₂ reductions, adding further impetus to the development of renewable energy options. US government schemes designed to encourage 'green' industries are also expected to play an important part in establishing renewable technologies.

Government subsidies are increasingly playing a role in encouraging solar generation, with feed-in tariffs in countries such as Germany, Spain, Italy and Greece making it economic for solar generators to feed power into the national grid systems. The authorities in Japan have indicated likely support for homeowner solar installations and US tax incentives are adding further impetus to these technologies.

Even without such subsidies, many systems already make economic sense and costs are anticipated to fall further as the technology matures with grid parity expected to be achieved over the next few years.

The NSG Group is well placed to supply all three of the leading solar energy technologies.

Thin film photovoltaic solar modules

Technology characteristics: Produces power at low cost per watt, but requires large surface areas for installations. Can be used in climates where the sun is not very strong and may be obscured by cloud.

Glass type required: Transparent Conductive Oxide Coating on float glass. The glass both lets light through and helps conduct the electricity produced.

NSG Group products: NSG **TEC™** is a high-performance, highly durable, electrically conductive glass used in a wide range of markets including photovoltaics, where it is used to construct thin film PV modules. With the Group's advanced technology, the coating properties can be 'tuned' to a wide variety of Thin Film PV technologies, including silicon and cadmium telluride based.

Crystalline photovoltaic solar modules

Technology characteristics: Highly efficient, but the PV cells are also expensive to make. So, best used in applications where space is at a premium. Requires reasonably high solar radiation, but can tolerate some cloud cover.

Glass type required: Low-iron rolled glass plus anti-reflective coating, to ensure that the maximum amount of solar radiation hits the PV cells.

NSG Group products: Pilkington **Sunplus™** is a high-performance, low-iron glass, designed to maximize solar energy collection through very high light and solar transmission. The high solar energy transmission of Pilkington **Sunplus™** makes it an ideal choice for crystalline PV photovoltaic solar cells.

Concentrated solar power applications

Technology characteristics: Typically, large area mirror arrays. Requires a large area and lots of sunshine. Particularly effective in sunny deserts.

Glass type required: Low iron float glass.

NSG Group products: Pilkington **Optiwhite™** is an ultra-clear float glass with very low iron content and its high solar energy transmittance makes it ideal as a base substrate for mirrors used in concentrated solar power applications.

Glass in Vehicles

The global automotive industry is increasingly addressing the sustainability agenda. The shift to electric vehicles and plug-in hybrids marks a new era, with CO₂ reduction a major focus. This requires glazing advances in solar energy control, weight reduction and energy saving.

As a world leader in automotive glazing, the NSG Group is meeting these challenges. It is developing automotive coating technology and glass compositions to produce advanced infra-red absorbing and high-performance infra-red reflecting technology. The Group aims to provide further opportunities for vehicle manufacturers to reduce CO₂ output.

Lightweight glazing

There can be over 13 individual pieces of glazing on a vehicle, all of which contribute to the overall vehicle mass and contribute significantly to the overall weight of the vehicle and to fuel consumption.

The NSG Group's developments have been heavily focused on the introduction of lightweight glass and glazing technology, with the launch of reduced thickness laminated and toughened sidelights, backlights and rooflights. Through continuous developments in the Group's glass-shaping capability to enable asymmetric windshield constructions, the Pilkington Automotive is contributing to the future of automotive glazing products.

With the Group's developing glass-shaping technology it is now possible for vehicle manufacturers to reduce the mass of glass components by up to 25 percent. Glass in vehicles offers more properties than simple transparency, so when designing vehicles for reduced mass in the components, consideration needs to be given to acoustics, stiffness, sealing and guiding systems and solar control.

Solar control technology

The relationship between high-performance solar control glazing and vehicle CO₂ emissions reduction has long been recognized. It has been established that control of the heat energy entering the vehicle will have a direct impact on mobile air conditioning usage and will lead to reduced fuel consumption and CO₂ output.

The Group's advanced solar control glass can make a significant contribution to the reduction of air conditioning usage by reducing solar heat gain. Approximately 30 percent of the heat loading on a car's interior comes through the windshield.

Pilkington Automotive's vehicle glazing products provide advanced solar control by absorbing or reflecting the infra-red energy from the sun. The Group's range of optimized green and privacy solar absorbing glasses can reduce the heat entering a vehicle by up to 65 percent.

Ensuring passenger comfort and safety

The Group develops and supplies not only glass but also glazing systems that are used to mount and seal the products in vehicle apertures. Pilkington Automotive is working constantly to decrease the component content, with a view to reduced cost and weight. New technology areas, for example, integral seals, significantly reduce processing steps and the amount of hardware needed to transform glass products to glazing products. Issues such as driver visibility and pedestrian safety overlay the Group's work in the development of the next generation of automotive glazing.

Glass and end-of-life vehicles

Glass typically constitutes around 3 percent of the composition of an average car. The automotive glass industry has not been directly involved in the setting of end-of-life Vehicle legislation, but the Group is actively involved in work on the elimination of harmful materials in glass, ink, solder and other components used for automotive glass products.

Appendix 1 - Glass Manufacture

Flat glass manufacture

Glass is obtained by the fusion of several inorganic substances. The fused mass is cooled to ambient temperature at a rate fast enough to prevent crystallization, i.e., the molecules cannot arrange themselves into a crystalline pattern. The fast rate of cooling to prevent crystallization applies to transparent glasses.

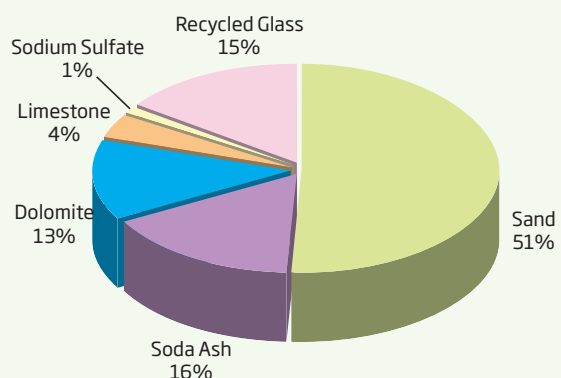
1. Raw materials and costs of flat glass

- The mix of raw materials used in the production of flat glass is known as the batch, which is mainly composed of three components: silica sand, soda ash and dolomite/limestone.
- Recycled glass (cullet) is used in the fabrication of flat glass and represents on average 15 percent of the materials used. Its addition helps reduce the energy required in the process.
- Silica sand, soda ash, dolomite and dolomite/limestone represent together 99 percent of all raw materials used in the production of glass, excluding recycled glass.

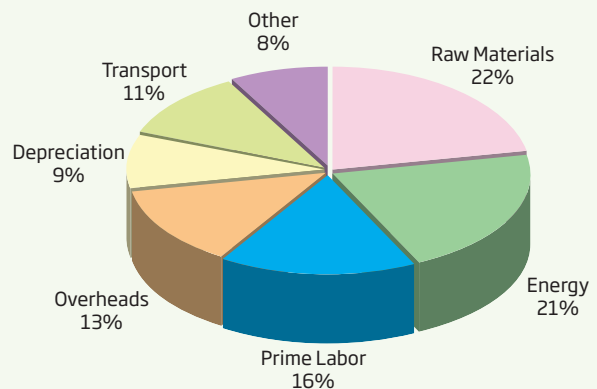
The remaining ingredients aid the melting and refining (bubble removal) reactions and impart color and there is water addition during batch mixing to prevent subsequent segregation.

Silica sand is the main component of the batch, as it constitutes about 62 percent of the batch weight excluding recycled glass. Soda ash is one of the most expensive raw materials used in glass manufacturing and represents about 16 percent of the batch weight but about 60 percent of the batch cost. In terms of costs, raw materials and energy are the single largest elements, followed by overheads and prime labor.

Float Glass Raw Materials



Float Glass Nominal Costs



2. Basic manufacture

There are three main flat glass manufacturing methods for producing the basic glass from which all processed glass products are made.

■ Float

Over 90 percent of the world's flat glass is made by the float process (see below). This is the way all of the world's high quality, optically clear glass is made.

■ Sheet

Approximately two percent of the world's flat glass is made by the sheet process. This process predates, competes with and is gradually being replaced by float. The majority of the world's sheet production is in China with the remaining pockets in the less developed markets of Africa, Eastern Europe and Asia.

■ Rolled

The rolling process makes patterned, figured and wired glass products. Semi-molten glass is squeezed between metal rollers to produce a ribbon with controlled thickness and surface pattern.

3. The Float Process

At the heart of the world's glass industry is the float glass process - invented by Sir Alastair Pilkington in 1952 - which manufactures clear, tinted and coated glass for buildings, and clear and tinted glass for vehicles. The process, originally able to make only 6mm thick glass, now makes it as thin as 0.4 mm and as thick as 25 mm.

Molten glass, at approximately 1000°C, is poured continuously from a furnace onto a shallow bath of molten tin.

It floats on the tin, spreads out and forms a level surface. Thickness is controlled by the speed at which solidifying glass ribbon is drawn off from the bath.

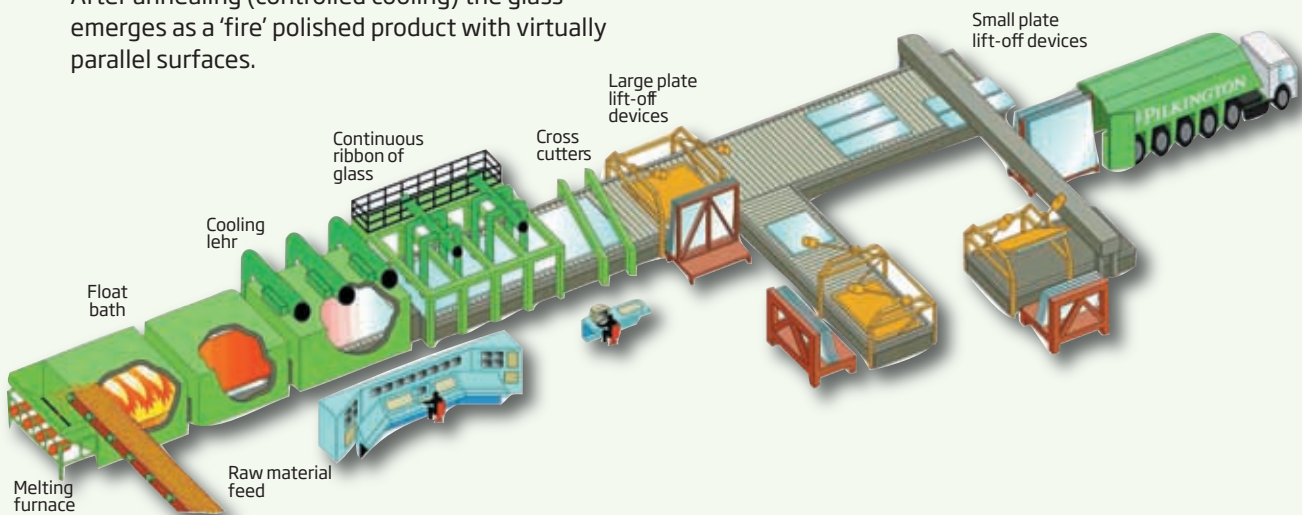
After annealing (controlled cooling) the glass emerges as a 'fire' polished product with virtually parallel surfaces.

A float plant, which operates non-stop for between 10-15 years, makes around 6000 kilometers of glass a year in thicknesses of 0.4 mm to 25 mm and in widths up to 3 meters.

The float process has been licensed to more than 40 manufacturers in 30 countries.

Over 380 float lines are in operation, under construction or planned worldwide with a combined output of about 1,000,000 tonnes of glass a week.

The NSG Group operates, or has interests in, 49 float lines worldwide.



3.1 Modified basic manufacture

There are three main forms of modification to the basic manufacturing processes.

Tinted

Extra ingredients are added to the raw materials of glass at the melting stage to produce tinted products. Cobalt and nickel tint glass grey; ferrous oxide tints glass blue, while ferric iron generates a yellow tint - both together tint glass green.

Tinted glass is used in buildings and vehicles to control heat and light transmission.

Coated (On-line)

Modified properties are produced from the basic glass by means of surface coatings. Glass can be coated on-line in the float process as the ribbon of glass is being formed in the float glass bath.

The technology uses chemical vapor deposition to apply a microscopically thin coating on the glass at a temperature of about 600°C.

Pilkington **K Glass™**, Pilkington **Energy Advantage™** and Pilkington **Activ™** are produced by this process.

4. Building Products processing

4.1 Semi-finished processing

The following types of processing are high volume and predominantly performed by glass manufacturers.

Coating (off-line)

Off-line processes use a vacuum coating technology called sputtering. A 'target' material is bombarded to produce atoms which are deposited on the glass.

This process is used to make products such as Pilkington **Optitherm™ S3** and Pilkington **Suncool™**.

Laminating

Plies of glass are bonded or laminated together with a layer of polymer film in between. By using heat and pressure, air bubbles are eliminated from the laminate so that it appears optically as a single sheet of glass.

Mechanically, however, it is more robust: if the laminate is fractured, the broken glass fragments are held together and are less likely to cause injury.

Laminated glass is used in safety and security applications.

4.2 Downstream processing

The following types of processing are performed by glass manufacturers and also by other companies.

Multiple glazed units

Multiple glazed units incorporate two (or more) panes, separated by spacers to create a hermetically sealed gap between each successive pane in the unit, e.g. Pilkington **Insulight™**. This gap can be filled with air, which is subsequently desiccant-dried, low conductivity gases such as argon can be used instead of air in the cavities or, in the case of the Group's **Spacia™** product, the layer of dry air is replaced by a vacuum to achieve higher performance.

Heat treatment

Toughened glass, or tempered glass as it also known, is produced when float glass is heated to around 650°C, then quenched with air jets so that the surfaces are cooled quickly, and the inside core more slowly. At room temperature, the core continues to cool. The surfaces go into compression and the core goes into tension. When the glass breaks, the core releases tensile energy resulting in the formation of small, safer glass particles. Toughened glass is used in safety glazing in buildings.

Shaping

Glass can be bent into shape for some building applications. Between 500°C and 600°C the viscosity - or syrupy nature - of glass falls by a factor of 10,000 as it transforms from a brittle solid to a plastic substance. The science of glass bending is to use this plastic phase to produce shapes that are free from wrinkles and other optical defects.

Sag-bending is the most widely used process. The glass is heated to the plastic phase and allowed to sag under its own weight to the required shape.

Surface working

Fine surface textures can be applied using sand blasting and acid etching.

Silvering

Float glass is made into mirrors in a process which deposits a thin film of high purity silver on one surface of the glass. A further thin film is then deposited to protect the silver from oxidation. Finally, a ceramic paint is applied.

This is the process by which Pilkington **Optimirror™ Plus** is made.

5. Automotive Products processing

Because glazing is an integral part of any vehicle's styling, each piece of automotive glass is unique to a specific opening within any individual vehicle. Hence three-dimensional shaping of the glass, together with imparting its increased strength and safety properties are at the heart of automotive glass processing. However, ahead of this, certain pre-process operations must be undertaken.

5.1 Pre-processing

Pre-processing involves a number of preparatory activities, ahead of submitting the glass to heat treatment.

They include:

- cutting out the flat glass template from standard, rectangular 'block sizes' of automotive float
- edge-working the shaped, but still flat, piece of glass to provide a smoothed glass edge
- drilling any required holes within the glass
- washing the glass, before clean-room printing is undertaken
- printing of shade bands, logos etc. on the glass in a single pass process for simple features but a two or three pass process for demisting circuits, antennas and alarms.

On completion of these pre-process activities, the glass proceeds to be shaped and to receive its safety properties.

5.2 Automotive glass shaping and strengthening

There are two basic forms of glass shaping and strengthening for automotive applications, though hybrid processes have more recently been developed.

Automotive toughening

Toughened glass, or tempered glass as it is sometimes called, is most frequently used in the rear and side windows of vehicles. It is designed to be much stronger than non-safety glass. However, in the case of a breakage, it shatters into very small pieces rather than sharp shards of glass, thereby significantly reducing the risk of injury.

This is made possible by the toughening process which introduces internal stresses into the glass through a combination of controlled heating to very high temperatures, (>640°C) and differential cooling.

The heating cycle is also used to shape or curve the glass, either by allowing the heated glass to 'sag' to a pre-defined mould shape under gravity, or for more complex shapes, by being pressed to shape by male and female moulds.

Automotive laminating

Lamination is a form of safety glazing where normally two thin glass plies create a sandwich around a polyvinylbutyral (PVB) interlayer. Normally used for a vehicle's windshield, in the case of breakage, the glass is held in place by the interlayer, retaining emergency visibility for the driver.

Laminated glazing is also increasingly being specified for car side windows.

Usually the glass plies are shaped (curved) as matched pairs through heating to a temperature of around 620°C. As with tempering, the shape can be achieved through gravity 'sagging' or through press-bending for the more complex shapes.

Differential heating to control temperature across the surface of the glass, and hence the resultant degree of bending, is also used for more complex shapes. The shaped glass pairs are then gradually cooled to room temperature before the PVB laminate is sandwiched between them.

At this point the PVB is opaque and only becomes transparent at completion of the lamination process.

This involves the removal of any air trapped in the glass sandwich through a mechanical or vacuum squeezing process, followed by heating of the windshield to 140°C within an autoclave, under a pressure of 10 to 15 kg/cm², to complete the bonding of the two glass plies.

Increasingly, glazing systems rather than a simple piece of glass are being supplied to the vehicle manufacturers. Much of this value-added activity is undertaken once the glass has been laminated or tempered.

5.3 Glazing Systems processes

Glazing systems help to simplify the vehicle assembly process. Modular systems such as encapsulation and extrusion are designed to facilitate adhesive bonding of the glazing to the vehicle.

Encapsulation

Encapsulation involves the injection molding of a polymer trim, shaped precisely to fit the vehicle body, to the periphery of the glazing. It also provides the opportunity to incorporate within the molding additional styling features, fixing mechanisms and even hinges for opening windows in minivans and estate cars.

Extrusion

An alternative glazing system is provided by the robotic extrusion of a polymer profile to the periphery of the glazing, with the extruded profile or seal being precisely shaped to the vehicle.

Assembly

Fixing of certain glazings within a vehicle can also be achieved through the application of locator clips to the glass. The attachment of such clips, together with other hardware, is most commonly referred to as assembly.

Appendix 2 - Float Operations

NSG Group and associates' global float operations

Location	Line	Completed	Comment
United Kingdom			
Cowley Hill	CH2	1972	
Greengate	UK5	1981	
	UK6	1992	
Germany			
Gladbeck	GL1	1974	
	GL2	1976	
Weiherhammer	WH1	1979	
	WH2	1991	
Italy			
San Salvo	SS1	1974	
Flovetro	FV1	1979	Flovetro (50%) - Managed by Saint-Gobain
Venice	VE1	1987	
Sweden			
Halmstad	SK1	1976	
Finland			
Lahti	L1	1987	Mothballed in 2009
Poland			
Sandomierz	PS1	1995	
Russia			
Moscow	RM1	2006	JV Managed by NSG Group
Japan			
Maizuru	M5F	1965	
	M1F	1998	
Chiba	V3F	1971	
	V1F	1986	
Malaysia			
Johor Bahru	JB1F	1993	
	JB2F	1997	
Vietnam			
Hanoi	VFG	1999	
Ho Chi Minh	VGI	2008	
USA			
Rossford	6F1	1970	
	6F3	1966	
Lathrop	10F1	1964	
Ottawa, Illinois	5F1	1970	
Laurinburg	75F1	1973	
	75F2	1980	
Argentina			
Lavallol	VV3	1989	VASA (51%) - Managed by NSG Group

NSG Group and associates' global float operations - continued

Location	Line	Completed	Comment
Brazil			
Jacarei	C1	1982	Cebrace (50%) - Managed by Saint-Gobain
	C3	1996	Cebrace (50%) - Managed by Saint-Gobain
Caçapava	C2	1989	Cebrace (50%) - Managed by NSG Group
Barra Velha	C4	2004	Cebrace (50%) - Managed by NSG Group
Chile			
Concepción	LQ1	1996	Vidrios Lirquen (26%) - Managed by NSG Group
China			
Changshu	CS1	2006	SYP-Pilkington 50:50 JV - Managed by NSG Group
	CS3	2009	Tianjin-SYP (10%) via SYP - Managed by SYP
Tianjin	T-SYP	1997	Tianjin-SYP (10%) via SYP - Managed by SYP
Suqian	CGH	1994	China Glass Holdings (29.9%)
	CGH	2002	China Glass Holdings (29.9%) Currently on extended cold repair
	CGH	2005	China Glass Holdings (29.9%)
Weihai	WE1	1995	China Glass Holdings (29.9%)
	WE2	2000	China Glass Holdings (29.9%)
	WE3	2003	China Glass Holdings (29.9%)
	WE4	2004	China Glass Holdings (29.9%)
Wuhai	WU1	1988	China Glass Holdings (29.9%)
	WU2	2001	China Glass Holdings (29.9%)
Xian	XI1	2005	China Glass Holdings (29.9%)
	XI2	2007	China Glass Holdings (29.9%)
Dongtai	DG1	2009	China Glass Holdings (15%)
	DG2	2010	China Glass Holdings (15%)
Beijing	CG1	2001	China Glass Holdings (29.9%). Closed in 2005
	CG2	1989	China Glass Holdings (29.9%). Closed in 2008

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