PILKINGTON
and the flat glass industry

2009
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Legal Notice
This document is intended as a briefing on the glass industry and the position within it of NSG Group’s Flat Glass Business, trading under the brand ‘Pilkington’. The content of the paper is for general information only, and may contain non-audited figures. Every care has been taken in the preparation of this document, but Pilkington Group Limited accepts no liability for any inaccuracies or omissions in it. Pilkington Group Limited makes no representations or warranties about the information provided within the document and any decisions based on information contained in it are the sole responsibility of the user. No information contained in this document constitutes or shall be deemed to constitute an invitation to invest or otherwise deal in shares in Nippon Sheet Glass Co Ltd.

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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. The decision was subsequently taken to brand the enlarged Group as ‘NSG Group’ and to use the ‘Pilkington’ brand for all of the Group’s Flat Glass businesses.

Consequently, in this publication, all references to ‘Pilkington’, with the exception of a few historical allusions, relate to the Flat Glass businesses of 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 Pilkington Automotive business, which is managed globally.

It should be borne in mind that the Flat Glass businesses of the NSG Group account for around 90 per cent of the NSG Group’s business by sales and that the Group also has a third business line, Specialty Glass, accounting for around 10 per cent of Group sales, which is not covered by this publication. As a result, 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 NSG Group itself is covered in Part Three of this publication.

Readers of this year’s report will be well aware that the financial year ended 31 March 2009 has been a very unusual one for the world’s Flat Glass industry, with a major disruption to normal trading patterns, particularly in the second half of the financial year. These factors have made the preparation of this year’s report particularly difficult. The unprecedented global economic downturn has severely affected glass demand in both the building and automotive sectors, leading to major disruptions in global demand, capacity utilisation, capital investment and normal growth patterns. The impact on individual companies, which make up the industry’s customer base, has been well documented. The past year has seen an unprecedented level of corporate activity, with some companies closing and others being sold or resorting to Chapter 11 protection. Although every effort has been made to record and reflect such activity, in some cases it has not been possible to update meaningfully and accurately some figures. Where this is the case, the previous year’s figures have been used. At the time of publication, the depth and duration of the current disruption is difficult to predict, and industry projections should be viewed in this context.

In January 2009, the NSG Group announced a restructuring programme, designed to protect the business in the short term and to re-establish growth from FY2011 onwards. As a result of the above measures, the Group will have reduced overall headcount by approximately 6,700 people by March 2010, representing a reduction of over 15 percent on June 2008 manning levels. Around 500 of these employees had left the Group by the end of the financial year under review. The Group’s BP business in Switzerland was sold to Flachglas Wernberg GmbH (in which the NSG Group has a 49 per cent stake) in July 2009. The majority of the Group’s downstream Building Products business in France was sold to Groupe Riou in October 2009.

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 2009, covering the fiscal year ended 31 March 2009.

This document is also available to download in pdf format from the NSG Group website at www.nsg.com.
The Flat Glass Industry and Global Market Structure

- The global market for flat glass in 2008 was approximately 53 million tonnes. At normal price levels, this represents a value of around euro 22 billion at primary manufacture level. Of this tonnage, around 70 per cent is consumed in windows for buildings, 10 per cent in glazing products for automotive applications and 20 per cent used in furniture and other interior applications.
- Over the long term, the market is growing in volume terms at around 4-5 per cent a year.
- Europe, China and North America together account for over 70 per cent of global demand for glass.
- Europe is the most mature glass market and has the highest proportion of value-added products.
- Four companies; NSG Group, Saint-Gobain, Asahi and Guardian, produce over 60 per cent of the world's high quality float glass. Much of the world’s lower quality float and sheet glass production is being replaced by high quality float.
- There are only three glass groups with global automotive glazing capability and presence. NSG Group (as Pilkington Automotive), Asahi, Saint-Gobain/Central, together with their respective associates, supply around 70 per cent of the world’s Original Equipment (OE) glazing requirements.

Glass - A Growth Industry

- Over the past 20 years, glass demand has grown more quickly than GDP. 2007 showed good growth globally, bolstered by China. Over the long-term, glass demand is still growing at just over 4 per cent per annum. In 2008, the industry was calculated to be running at around 93 per cent utilisation on average.
- Demand growth for glass is driven by economic growth and by legislation and regulations concerning safety, noise attenuation and the response to the growing need for energy conservation.
- Architects and car designers continue to increase the glass content in buildings and vehicles.
- Demand for value-added products is growing at a faster rate than demand for basic glass, enriching the product mix and boosting the sales line.
- Value-added products are delivering greater functionality to vehicle glazing and adding a further growth dimension to automotive glazing sales.

Pilkington - A Leading Brand in a Growth Industry

- The NSG Group, trading under the Pilkington brand in the Flat Glass sector, is one of the world’s largest manufacturers of glass and glazing products for the building and automotive markets, with manufacturing operations in 28 countries on four continents and sales in 130 countries. Overall, the NSG Group had sales of around euro 5.5 billion in the fiscal year ended 31 March, 2009.
- NSG Group is the most focused glass company and, together with its associates, has wide global reach. The Group’s Flat Glass businesses, trading under the Pilkington brand, have strong market positions in Building Products and Automotive OE and Automotive Glass Replacement (AGR) sectors.
- The Pilkington brand is synonymous with Flat Glass manufacturing excellence and innovation, with a reputation for leading many important technological advances in the glass industry, including the Float process, now the world standard for high quality glass production.
- In FY2009, 48 per cent of Group sales were generated by Building Products and 42 per cent by Automotive. The Group's Specialty Glass business, not covered in this publication, accounted for 10 per cent of Group sales.
Geographic Positioning: Building and Automotive

- The NSG Group has a wide geographic reach, enabling it to respond to customers whose operations, particularly in the case of Automotive OE, are increasingly global.
- Pilkington Automotive is a world leader in the supply of Automotive Glass Replacement products for the Automotive aftermarket.
- The Group’s Flat Glass business, operating under the Pilkington brand, has manufacturing operations in 28 countries and sales in 130.
- Worldwide, the NSG Group operates, or has interests in, 49 float lines.
- The Group’s Automotive business, Pilkington Automotive, is a leading supplier to the global automotive glazing industry.
- The Group has established a Solar Energy business unit to exploit the growing demand for glass in photovoltaics.

Technical Leadership

- Pilkington played a key role in the industry’s technological advances in the 20th century including Sir Alastair Pilkington’s invention of the ‘float’ glass process.
- The Pilkington brand is synonymous with technological excellence, which is widely recognised by its competitors and customers alike.
- Pilkington Activ™, the world’s first dual-action self-cleaning glass, is on sale in major markets worldwide. An extended range of Pilkington Activ™ derivatives now offers self-cleaning properties in combination with solar control coatings, low-emissivity energy-saving glass, laminated safety glass and noise-reduction laminates.

Strategic Direction

- Following the acquisition of Pilkington, the NSG Group announced a three-phase, 10-year strategy, during which the newly expanded company will steadily implement growth strategies.
- The Flat Glass businesses, Building Products and Automotive, operating under the Pilkington brand account for just under 90 per cent of the Group’s total sales.
- Sharing of advanced manufacturing technologies has led to significant improvements in productivity, subsequently helping to reduce the unit cost of producing goods.
- A sound base has already been established in China as a platform for future growth, with Chinese Automotive plants now integrated into the Group’s global Automotive glazing operations and a growing presence in Building Products.
- An Automotive line in Vizag, southern India, started production in late 2008.
- Despite the current downturn in international trade, the Group has made good progress on its strategic objectives and attained its net debt target of JPY350 million one year ahead of schedule.
- A new integrated global organization has now been established, with good progress on the realization of synergies.
- The Group is in Phase 1 of a 3-phase strategy. The key objectives going forward are to create an international, integrated, global company, maintain net debt at target levels and prepare the Group for growth.
1. THE FLAT GLASS INDUSTRY AND GLOBAL MARKET STRUCTURE

1.1. Total World Market for Flat Glass

The global market for flat glass\textsuperscript{A} in 2008 was approximately 53 million tonnes (~6.6 billion m\textsuperscript{2})\textsuperscript{B}. At normal price levels, this represents a value at the level of primary manufacture of around euro 22 billion. Over the long term, this market is growing in volume terms at around 4-5 per cent a year.

Of this demand, over 32 million tonnes is high quality float glass. Around 2-3 million tonnes is satisfied by sheet glass production (a process where molten glass is drawn out of the furnace vertically and subjected to an inferior annealing process); and 2 million tonnes is rolled glass (a process where molten glass is squeezed between rollers to form sheets, usually with a pattern embossed on the surface). The remaining 17 million tonnes is lower quality float, produced mainly in China. Rolled glass demand is expected to grow as new facilities are commissioned which will manufacture glass for solar applications.

A proportion of the high quality float glass, and indeed some of the rolled, is further processed by laminating, toughening, coating and silvering, for use typically in insulating glass units or automotive glazings. At this level the market has a value of approximately euro 52 billion.

\textsuperscript{A} – Glass manufactured in flat sheets (float, sheet and rolled), which may be further processed. Excludes bottles, containers, fibreglass, rods, and tubes.

\textsuperscript{B} – On average 1 tonne is approximately 125 m\textsuperscript{2}.

1.2. Routes to Market

The following chart 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 (~45 million tonnes) with ~5 million tonnes going to Automotive. Special applications 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.
1.3. Industry Economics

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

The economics of the continuous-flow float operation require a high capacity utilisation rate before a plant becomes profitable. Once that rate, around the 70 per cent range, is passed the inherent operational leverage of the asset base increases profitability rapidly. Product diversity, in both glass composition and thickness, can reduce nominal 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 minimised through coordinated production scheduling of regional float assets.

The float process is not labour-intensive. Energy and raw material costs are each as significant as factory labour in the overall delivered cost. Glass is relatively heavy and comparatively cheap, making distribution costs significant; they typically represent around 15 per cent of total costs. In most cases, transport costs make it uneconomic for float glass to travel long distances by land. Typically, 200 km is 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 favour float lines with local port access unless a local market is available for the line’s output.

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 42 million and euro 63 million, depending upon the technology employed, the degree of automation and its location. Annual revenue from such an investment would be approximately euro 49 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 militate 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 labour intensive than float manufacturing, and growth in value-added activities is increasing this requirement.

Automotive glass can and does travel significant distances and, whilst 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.
1.4. Global Players and Market Shares

Considering high quality float alone, the industry is relatively consolidated, with four companies manufacturing over 60 per cent of the glass produced in the world and three supplying around three quarters of the glass used in the automotive industry.

Of the four companies manufacturing most of the world’s glass, two are Japanese, one French and one American.

**World High Quality Float Capacities 2008**

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Percentage of World Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGC</td>
<td>Japan</td>
<td>17.0</td>
</tr>
<tr>
<td>NSG Group</td>
<td>Japan</td>
<td>17.0</td>
</tr>
<tr>
<td>Saint-Gobain</td>
<td>France</td>
<td>14.0</td>
</tr>
<tr>
<td>Guardian</td>
<td>United States</td>
<td>12.0</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>40.0</td>
</tr>
</tbody>
</table>

1. The country in which the parent company is domiciled.
2. Including affiliates.

Portfolio Comparison of the Major Players

In terms of the size of their respective flat glass businesses, the world’s top five companies are led by the NSG Group and AGC. Saint-Gobain comes in at number three, followed by Guardian Industries.

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 PPG.

Following the acquisition of Pilkington by NSG, just less than 90 per cent of the combined entity is concerned with Flat Glass, significantly higher than the nearest rival, Asahi at 50 per cent. World number three, Saint-Gobain’s flat glass focus is the lowest of all five majors, at just 13 per cent.
1.5. World Float/Sheet Glass Markets

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

- Europe
- Japan
- South East Asia
- North America
- South America
- China
- Russia/Former Soviet Union
- Rest of the World

In this and subsequent analysis rolled glass is excluded and unless otherwise stated market figures are 2008 estimates.

General Overview

The global market for flat glass in 2008 was approximately 53 million tonnes. This is dominated by Europe, China and North America, which together account for over 70 per cent 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 over 40 per cent.

Regional Float & Sheet Demand 2008

Europe

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

Europe, with a market size of around 10 million tonnes, has eight main indigenous manufacturers of float glass: Saint-Gobain, NSG, AGC, Guardian, Sisecam, Euroglas, Sangalli and Interpane. Scheuten, a European glass processor, part owns a float line with AGC. Europe is a mature market with a high proportion of value-added products such as coated and laminated, manufacture of which is largely in the hands of float manufacturers. Per capita glass consumption is around 16 kg.

Downstream processing, into Insulating Glazing Units for example, is generally in the hands of smaller independent players. Saint-Gobain, NSG and AGC participate at this level of the market, but with lower market presence than in primary manufacturing.

European Float/Sheet Capacity by Company

Total capacity is almost 11 million tonnes, of which only around 50,000 tonnes is sheet.
As of the beginning of 2009, new float capacities by Euroglas and Interpane/Scheuten are assumed to come on-stream in the second half of the year. Several companies have also stated their intentions to construct manufacturing facilities focused on serving the growing Solar Energy sector (not shown on the map). However, new float investment plans in Europe for 2009-2010 and possibly beyond, have been affected by the slump in the construction industry.

**Japan**

There are three float glass manufacturers in Japan: NSG Group, AGC and Central Glass. The overall market size for float is almost 1 million tonnes, and per capita glass consumption is around 8 kg. Total float capacity is over 1 million tonnes.

**Japanese 2008 Float Capacity by Company**

The total float capacity is over 1 million tonnes.
South East Asia
The market size is in excess of 4 million tonnes. Over 30 float lines are operating in this region, which are owned by seven main glass manufacturers and several local concerns. Per capita consumption is around 6 kg.

South East Asia Float Capacity by Company

Total capacity is over 4.5 million tonnes of which approximately 300,000 tonnes is accounted for by sheet glass.
At a primary level, the Flat Glass industry in North America has nine players.

North America

North America is defined as USA, Canada, Mexico, Central America and the Caribbean islands. North America is a mature glass market with annual consumption of around 10 kg per capita. The Industry, at the primary level, has nine players (note that new players emerged in 2008 after Zeledyne acquired the former Ford Glass business from ACH and PGW was set up to run PPG’s former automotive glass business).

North American 2008 Float Capacity by Company

The total capacity is around 6 million tonnes of high quality float glass.
In South America, there are three manufacturers of high quality float glass: the NSG Group, Saint-Gobain and Guardian.

South America

South America has a market size approaching 2 million tonnes, and annual per capita glass consumption of around 5 kg. There are three manufacturers of high quality float glass: the NSG Group, Saint-Gobain and Guardian. Six of the eight float lines in this region are joint venture operations between the NSG Group and Saint-Gobain, of which four are managed by the NSG Group.
South American Float Lines

Total capacity is over 1 million tonnes, of which a small amount (<100,000 tonnes) is sheet glass.

China

In 2008, China float and sheet glass output reached over 24 million tonnes. China produces just under 50 per cent of the global output of flat glass.

As of June 2009 there were around 200 float lines installed in China, of which only around 150 were operating and only 40 were of a western-style design. Nevertheless, the quality and output of Chinese float is increasing quickly. In terms of consumption and output, the market had been growing faster than 10 per cent per annum until 2008 when global recession caused a sharp contraction. A number of float lines have been stopped, but growth is expected to resume by 2010.

Currently, approximately 1.5 per cent of Chinese flat glass demand is imported, mainly specialised products that are not yet produced in China, while around 15 per cent of the domestic float glass output is exported, mainly standard glazing products into the rest of Asia and Russia.

Further processing of float glass is still at low levels compared to Europe and North America, but is showing strong growth as the quality of domestic and commercial developments improves. Most of the housing market still uses monolithic, uncoated clear glass but, in response to the need to cut carbon emissions, building regulations are changing in a way that will rapidly increase the use of value-added low-e glass in many parts of the country.
Total capacity is around 27.5 million tonnes, of which approximately 12 per cent is sheet glass.

Chinese Float Lines of Western Design
There are currently 19 flat glass manufacturing operations in the FSU, 13 float lines and 6 which still use sheet technology.

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

**Former Soviet Union (FSU)**

There are currently 19 flat glass manufacturing operations in the Former Soviet Union, thirteen float lines and six which still use sheet technology. Most of these plants, including all of the sheet glass operations, are limited in the quality of glass they can manufacture, which is inferior to the modern float glass production found in Europe.

The demand for both high quality float glass and value-added glass products, such as energy-saving low-e, glass continues to grow. The total market size in 2008 was estimated to be around 2.7 million tonnes. In response to this growth, several new western quality float glass plants were commissioned in recent years, including Pilkington’s own joint venture float line near Moscow in 2005 and Guardian’s new float facility in Ryazan in 2008. Three new lines are expected to start operations in 2009: AGC and Saratov in Russia and Gomel in Belarus. Demand growth has been fuelled by new-build activity and residential refurbishment work. The FSU glass market is expected to contract by almost 20 per cent in 2009, as a consequence of the economic slowdown, and to resume moderate growth from 2010.

**Former Soviet Union Float/Sheet Glass Capacity by Company**

The total capacity is over 2 million tonnes, of which slightly less than 250,000 tonnes is sheet glass.
Rest of the World

The glass market is generally much less mature, with annual per capita consumption levels averaging 1 to 2 kg. Furthermore, there is a greater proportion of sheet and lower quality float capacity, which will gradually be phased out and replaced by high quality float.

1.6 Automotive

Market Overview

There are two routes to market for automotive glass:

a) Original Equipment (OE) supplied to Vehicle Manufacturers (VMs) for new vehicles.

b) Automotive Glass Replacement (AGR) product, supplied to the aftermarket for retrofit purposes, usually following damage.

Globally, OE glass demand is estimated to be around five 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 96 per cent of global vehicle 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 Asahi. Saint-Gobain is the third global player.

OE Light Vehicle Market

Light vehicle production in 2008 was 65 million, of which 41 per cent was in the two main markets of Western Europe and North America. Build in Japan contributed a further 16 per cent. Not only do these three regions account for 67 per cent of global LV production, but they are also the domiciles of most of the world’s VMs and as such are the centres 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.
Reflecting the importance of both technical capability and geographic presence in serving the light vehicle market, around 70 per cent of global demand is supplied by the three global automotive groups, the NSG Group, Asahi and Saint-Gobain with its strategic partner Central.

Other major suppliers in 2008 were PGW (formerly PPG) with operations primarily in North America, (a majority shareholding in this business is now owned by New York based private equity firm Kohlberg & Company), Zeledyne, the North American based former Ford Glass/Visteon business, Fuyao, the largest Chinese supplier and growing outside its home market, and Guardian with operations in the US and Europe.

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 per cent of the market.

Subsequent restructuring at GM and DaimlerChrysler involved divesting their respective stakes in Fiat, Suzuki, Subaru, Isuzu, Mitsubishi and Hyundai, and more recently the sale by Daimler of its stake in Chrysler and Ford’s divestment of the Land Rover and Jaguar marques to the TATA Group.

In 2008, the six largest VMs with their affiliates accounted for 61 per cent of global production. The principal brand memberships of the major VM groupings (pre restructuring in the wake of the global recession) are listed on the next page.
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.

Europe Overview

Even with the market turmoil of 2008, the European OE market remains the largest (31 per cent 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 2008 Western Europe accounted for almost 70 per cent 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 below, with successive Japanese investment in recent years supplementing the existing presence of the traditional European VMs.

2008 Light Vehicle Production Western Europe – 14.3 million

Besides the Toyota, Nissan and Honda build separately identified above, other Japanese VMs now present in Western Europe are Mitsubishi, Mazda (part of Ford), and Suzuki.
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.

**2008 Light Vehicle Production Eastern Europe – 6.2 million**

OE glazing supply in the Western European OE market is predominantly by the local operations of Saint-Gobain, Pilkington Automotive and Asahi. A few smaller manufacturers, including Soliver, Rigiglass and Guardian, together with a small amount of imports, supply the remainder of the Western European market (~12 per cent). Local independent glass processors are believed to have a larger share of certain Eastern European markets.

**North America Overview**

Though much reduced from 2007 levels, NAFTA still comprised the second largest OE market in the world in 2008, with 12.6 million vehicles. 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. Nevertheless, in 2008 the ‘Big Three’ VM groups still held almost 60 per cent of the market.

**2008 Light Vehicle Production NAFTA – 12.6 million**

The OE glazing supply base in NAFTA is one of the most diverse of all regions. Four companies have market shares estimated in excess of 15 per cent; two more companies have shares of around 10 per cent, with all of the remaining suppliers having shares of less than 3 per cent.
The leading supplier is PGW, followed very closely by AGC and Pilkington Automotive. The fourth and fifth spots are currently occupied by VVP of Mexico and Zeledyne (formerly Ford Glass). Next comes the strategic partnership of Saint-Gobain’s Sekurit business and Central Glass’s Carlex subsidiary, with privately held Guardian together with imports taking the remainder of the market.

**Japan Overview**

In 2008 Japan remained the third largest automotive market in the world behind Europe and North America, with annual light vehicle production of 10.7 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 Ford’s 33 per cent in Mazda, Renault’s 44 per cent in Nissan, and until recently, DaimlerChrysler’s holding in Mitsubishi and GM’s interests in Subaru, Suzuki and Isuzu. To date, only two of the Japanese VMs, Toyota and Honda, have remained independent of equity investments by US or European VMs.

In the case of Renault’s investment in Nissan and Ford’s in Mazda, the management influence of the non-Japanese partner is today of great significance.

In Japan, as elsewhere in the world, Toyota, Honda and Nissan are the largest of the Japanese VMs. Together these three VM groups account for 67 per cent of light vehicle production in Japan.

2008 Light Vehicle Production Japan - 10.7m million

Supply of OE glazings in Japan is in the hands of the three domestic glass companies, Asahi Glass, NSG Group and Central Glass. Asahi is believed to have just over half of the market and the NSG Group around 30 per cent, 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.
China Overview

Consistent double-digit growth in recent years has seen China rise rapidly to be the fifth largest ‘regional’ market behind Europe, North America and Japan in 2008, and the third largest behind the Japan and the US in individual country terms. In 2008 light vehicle production in China totalled 7.3m units. This development is on the back of inward investment by all of the major VMs as well organic growth by China’s own domestic vehicle manufacturers which together still account for more than 40 per cent of the market.

2008 Light Vehicle Production China – 7.3m million

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

Rest of Asia (excluding Japan and China) Overview

At 8.9 million vehicles in 2008, Asia, excluding Japan and China, is now the fourth largest regional market. In automotive market terms, the region is not homogenous, 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. However, the regional economic crisis of the late 1990s led the over-stretched Korean VMs into serious financial difficulties, providing opportunities for Western VMs to take strategic investments. DaimlerChrysler took a 10 per cent equity stake in Hyundai in 2001, whilst Daewoo finally struck a deal with GM in 2002. This involved the establishment of a new joint venture company GMDAT, comprising selected domestic and foreign assets of the bankrupt Daewoo Motor. Whilst DaimlerChrysler continued to maintain a strategic relationship with Hyundai, it did not retain an equity interest in the company.

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. Asahi 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, Asahi 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, have both followed suit. The NSG Group today has automotive glass affiliates in Malaysia, Taiwan and China, with Central having a Taiwanese joint venture.

The Western glassmakers have also begun to build strategic presences in the key Asian markets. 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.

South America Overview

South America is the sixth largest vehicle-producing region in the world, with Brazil and Argentina together accounting for around 92 per cent 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.
Saint-Gobain, through its Brazilian and Colombian subsidiaries and NSG Group through its Pilkington operations in Brazil, Argentina and Chile, have similar sized market shares, together accounting for over 90 per cent of South American glazing demand with the remaining supply coming from independent domestic processors, and imports.

**Rest of the World Overview**

Iran, South Africa, Egypt and Morocco comprise the principal OE markets elsewhere in the world, accounting for just under 3 per cent of global volume.

**2008 Light Vehicle Production Rest of World – 1.7 million**

The South African market is principally served by Shatterprufe, the automotive glass subsidiary of domestic flat glass manufacturer, the PG Group.
2. GLASS – A GROWTH INDUSTRY

2.1. Global Demand for Flat Glass

Over the long term, demand for float glass is growing at over 4 per cent 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 two percentage points.

Global Float Demand Grows c. 4.2 per cent p.a. In 2009 Demand Contracts by 10 per cent

The world flat glass market is expected to decline to 48 million tonnes in 2009, including 2 million tonnes of rolled glass.

Until this year, global float capacity utilisation has ranged between 90 and 95 per cent (virtually the practical limit for a network of float plants, since having all of the right thicknesses in the right place at the right time is not generally achievable). In 2008, the industry was calculated to be running at around 93 per cent utilisation on average.

Global capacity utilisation will drop significantly in 2009 after a sharp tightening of demand due to the global recession. Although the industry has moved to reduce capacity, utilization is expected to dip to around 87 per cent.
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 is 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**

In 2008, a new float line represented less than 0.3 per cent of global installed capacity.

A new float line added in 1970 represented more than 3 per cent of global float capacity. A new line in 2008 represented less than 0.3 per cent 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 summary

- Over the long term, demand is growing steadily in most regions.
- The global recession has caused a demand contraction in 2009. Recovery is uncertain and return to 2007 levels is not expected until 2012.
- Growth of coated glass has the effect of reducing float capacity as output is effectively lower.
- Global capacity utilisation is expected to be greater than 90 per cent in the medium term.
- The pace of capacity addition outside China has moderated recently, with four new lines on stream in 2008 but a further nine planned for 2009.

New float build programme

The following table shows lines that have come on stream since 2008, and those planned to start-up in 2009. In addition, 13 float lines are believed to have come on stream in China in 2008.

<table>
<thead>
<tr>
<th>Country</th>
<th>Company</th>
<th>Start Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech Republic</td>
<td>AGC</td>
<td>2008</td>
</tr>
<tr>
<td>Vietnam</td>
<td>NSG</td>
<td>2008</td>
</tr>
<tr>
<td>Russia</td>
<td>Guardian</td>
<td>2008</td>
</tr>
<tr>
<td>Poland</td>
<td>Saint-Gobain</td>
<td>2008</td>
</tr>
<tr>
<td>India</td>
<td>Gold Plus</td>
<td>2009</td>
</tr>
<tr>
<td>Brazil</td>
<td>Guardian</td>
<td>2009</td>
</tr>
<tr>
<td>UAE</td>
<td>Emirates Glass</td>
<td>2009</td>
</tr>
<tr>
<td>India</td>
<td>Sejal</td>
<td>2009</td>
</tr>
<tr>
<td>Belarus</td>
<td>Gornel</td>
<td>2009</td>
</tr>
<tr>
<td>Russia</td>
<td>AGC</td>
<td>2009</td>
</tr>
<tr>
<td>Russia</td>
<td>Saratov</td>
<td>2009</td>
</tr>
<tr>
<td>Poland</td>
<td>Euroglas</td>
<td>2009</td>
</tr>
<tr>
<td>Germany</td>
<td>F Glas</td>
<td>2009</td>
</tr>
</tbody>
</table>
Regional Analysis

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

Europe  Japan  South East Asia
North America  South America  China
Former Soviet Union

Analysis of demand and capacity utilisation 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 per cent range from 2000 to 2007, but the recession that hit in the second half of 2008 led to a contraction in demand, whilst significant new capacity came on stream. Further new capacity, from projects begun prior to the recession, is due to come on stream in 2009, but the industry has moved to reduce overall capacity through extended repairs and other shutdowns. As a result, the unprecedented fall in demand, anticipated to be around 20 per cent, is expected to drive utilization down temporarily to around 80 per cent.

European Capacity Utilisation

In Japan, recession is expected to hold utilization under 80% until beyond 2010.

Japan

Demand in Japan has been relatively flat, at just over one million tonnes, during this decade.

Until 2006, available capacity had been in decline for over a decade as lines were mothballed, or converted to produce glass for specialist applications. Some capacity has recently been brought back on stream, bringing industry utilisation back below 100 per cent. As with most other regions, recession in 2008 has reduced demand to less than one million tonnes and utilization is expected to remain below 80 per cent until after 2010.
South East Asia

As with Japan, the regional demand has been in recovery mode since the financial crisis of the mid 1990s, which reduced the glass market size in the ASEAN region by around a quarter. Since then, demand has grown in line with or slightly in excess of global growth. This trend looks set to continue.

Available capacity has increased in recent years as some of the plants mothballed after the crisis of 1998 have been brought back on stream, and since 2006, new capacity has been added in Indonesia, Taiwan and Vietnam.

The global recession is expected to reduce regional demand by 10 per cent, since the peak of 2007, and utilization is forecast to remain below 95 per cent.

South East Asia Capacity Utilisation
North America

North America was the first region to fall victim to recession and demand has contracted since the peak of 2006. This demand picture is a similar to that in Europe, but the crucial difference has been the corresponding stabilisation, and even reduction, in capacity as lines have been taken out of action. Since 1998 the following closures have occurred: Dearborn (Ford), Perry (PPG), SC3 (AGC), Nashville (Ford), Mexico City (VVP), Cinnaminson (AGC), Owen Sound (PPG), Greenland (AGC), Victorville (AGC) and Quebec (AGC). Several facilities are also expected to undergo lengthy repairs or other forms of capacity reduction during 2009.

Regional capacity utilisation is expected to dip below 90 per cent again in 2009.

South America

South American glass demand has been steadily growing since 2003. However, the global recession has had its negative impact on regional glass consumption. Although regional demand still exceeds local capacity the gap is narrowing. The new float builds and planned expansions in plant capacity of existing facilities will bring this into balance.

Regional capacity utilization reached its peak in 2008 at around 150 per cent but is expected to fall in 2009 and 2010.
China

Since 2000, there has been a major float build programme in China, and the number of float lines has increased to around two hundred. This has resulted in a significant downturn in utilisation to less than 85 per cent. Utilisation is expected to stabilise as the pace of capacity addition slows down.

Glassmakers will accelerate their plans to eliminate outdated facilities, and shift their focus to technical renovation of their current lines, rather than investing in new projects.

**China Capacity Utilisation**

Former Soviet Union

The regional flat glass demand has been growing robustly since the relative low point of 2000 up until 2008, with the market size more than doubling in eight years. As a consequence of global recession, market demand is expected to fall in 2009, with moderate growth resuming in 2010.

Capacity utilization is likely to drop sharply in 2010 if announced capacity additions are brought on stream.

**Former Soviet Union Capacity Utilisation**
2.2. 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 maximising natural daylight. This has been achieved through the use of larger glazed areas in façades and roofs, and through entirely glazed facades 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 per cent of glass consumption worldwide. In mature markets, windows in residential buildings are replaced every ten to twenty years.

Energy Efficiency

Over the past 25 years, in mature markets such as Europe, Japan and North America, the growing need for energy efficiency has encouraged a switch from single glazing to insulated glazing units (also known as double-glazing). As well as being a higher value product for the industry, a double glazing unit consumes more than twice as much glass to fill the same hole in a building’s wall. This was taken a stage further as Kyoto CO2 targets, climate change, escalating fuel prices and concerns about energy security, have driven tougher legislation for energy-saving glass, thus making insulated glazing units mandatory in most parts of Europe and introducing legislation requiring energy efficient coated glasses. There is growing governmental support worldwide for renewable energy generation, including Solar.

European Energy Legislation Summary

At EU level, energy efficiency is becoming an ever higher political priority. In 2006 the European Commission published its “Action Plan for Energy Efficiency”, and in 2007 a formal overall EU energy policy was published. These documents show that improving energy efficiency is now at the heart of the EU’s energy and climate policy, and the current target is to reduce the EU’s CO2 emissions by 20 per cent by 2020. Buildings are identified as a priority. The role of renewables is enhanced; the EU Action Plan has set a target of 20 per cent of electricity being generated by renewable energy by 2020.

Underpinning these policies has been a series of EU Directives (which have to be implemented by all 27 Member States). One Directive, commonly referred to as the Energy Services Directive, required each Member State to draw up a National Energy Efficiency Action Plan in 2007. It is clear from these Plans that improving the energy efficiency of buildings is a priority in many cases. Another Directive – the Energy Performance of Buildings Directive – imposes a raft of obligations on Member States, including the requirement to upgrade their Building Regulations for energy every five years.
Building Regulations continue to be the major driver for high performance and added-value glass, particularly in the area of energy efficiency. Because of the recent EU Directives, Building Regulations are now under almost continual review in most countries, but the current situation includes:

- All central and northern European countries, and indeed some southern countries (such as Italy), have legislation requiring energy efficient (low-e) coated glass in new buildings
- Germany, UK, France and Ireland have legislation requiring low-e glass in all replacement windows
- Low-e introduction in Poland has followed that of Germany

Countries are increasingly turning their attention to air-conditioned buildings, creating increased possibilities for regulations to encourage solar control glass.

In central and northern European countries, the longer term plans of most governments include progress towards triple glazing becoming the regulatory norm.

An example of the effect of Building Regulations is the sharp increase in demand for low-emissivity (low-e) glass in Germany in the 1990s from under 2 million m² 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 IGUs to around 50 per cent. Low-e glass is now standard in Germany and the experience has been repeated in the UK. The trend is expected to be repeated in France and other countries over the next two to five years, as legislation comes into force, dramatically increasing the demand for low-e coated glass from around 60 million m² to around 100 million m².

**Energy Legislation – Germany & UK**

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

A further way of reducing energy usage is through the use of solar control glass. These products have special coatings applied to their surface which reflect up to 75 per cent of the solar heat whilst 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 metre 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 same energy efficiency drivers are also resulting in the increased demand for photovoltaic and solar thermal energy panels. Spain has recently introduced Building Regulations making the use of photovoltaic and solar thermal panels mandatory in new buildings. Many other countries have introduced grants and other fiscal incentives towards their installation. In all of these systems, glass is an essential integral component.
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.

New products

The industry is constantly developing new and innovative glass products and the NSG Group is at the forefront of these developments. These products are invariably value-added and although they sometimes substitute lower value products; overall the product mix is enriched.

This product mix enrichment is illustrated by the development in the European glass industry over a 10-year period. Basic float glass, which in 1995 accounted for around 66 per cent of the industry’s revenue, now accounts for only 42 per cent.

European Market Structure Product Mix (by Value)

<table>
<thead>
<tr>
<th>Year</th>
<th>Product Mix</th>
<th>Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Basic Float 66%</td>
<td>~USD 3 Bn</td>
</tr>
<tr>
<td>1995</td>
<td>Silvered 13%</td>
<td>Fire 6%</td>
</tr>
<tr>
<td>1995</td>
<td>Laminated 7%</td>
<td>Coated 8%</td>
</tr>
<tr>
<td>2006</td>
<td>Basic Float 42%</td>
<td>Fire 11%</td>
</tr>
<tr>
<td>2006</td>
<td>Silvered 8%</td>
<td>Laminated 14%</td>
</tr>
<tr>
<td>2006</td>
<td>Coated 25%</td>
<td></td>
</tr>
</tbody>
</table>

2.3. Automotive Glazing Industry

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 per cent to 80 per cent by 2004. Recent industry restructurings, particularly those within the GM, Ford and DaimlerChrysler Groups now see a slightly differently constituted group of the six largest VMs accounting for 61 per cent 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, Asahi and Saint-Gobain/Central, increasing their combined global market share from 49 per cent to an estimated 70 per cent.

Alternative consolidation trends can be expected as VMs seek to maximise 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 favour 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’ (JIT) 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 globalisation 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 global industry has exhibited steady growth; an average of around 2 per cent per annum over the last 11 years, even with the short-lived downturns in 1998 and 2001. However, the downturn which hit the industry in 2008 and 2009 on the back of the global economic crisis has been unprecedented both in terms of its spread and its scale. Its severity means that recovery, though now underway in several markets, will be slow overall, with the developing markets leading the way.

*Global Light Vehicle Build - 1997 to 2013*
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 are the principal centres 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 per cent of global vehicle production in 1991. By 2008 their share had risen to 43 per cent and is expected to increase to 51 per cent by 2013.

The annual average growth of these combined developing regions between 1997 and 2008 was over 7 per cent, a rate that is currently expected to be maintained on average going forward, though the effects of the recession will result in reduced growth in the short term.
Of the developing regions, China has been the best performer to date, exhibiting average growth of 19 per cent per annum since 1997. Vehicle build in Eastern Europe has also shown good growth averaging 8 per cent since 1997, followed by the rest of Asia at around 5 per cent per annum.

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 per cent per annum over the five years to 2013.

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.

Over the last 35 years, glazing area on equivalent models has increased in the order of 50 per cent. Average windshield glazed area has increased by over 60 per cent 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 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. There can be anything from six 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 windscreens 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 simple piece of glass. Such systems use innovative finishing technologies, including encapsulation and extrusion, 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, 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, we see the introduction of regional regulatory glazing performance standards for automotive. California has taken the lead with very specific glazing standards being specified by the California Air Resources Board on model year 2012 vehicles sold in the state of California. The objective of the glazing standards is to help decrease in-vehicle temperatures and directly reduce the CO2 output by having a lower requirement on the engine-driven mobile air conditioning unit. These regulatory requirements 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 other regions of the world adopt CO2 reduction glass technologies is yet to be fully understood.

By way of illustration, the chart below 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. By 2008, vehicle growth and glazing value growth has been 13 per cent and 41 per cent respectively. By 2014, equivalent growth numbers are estimated to reach 17 per cent and 52 per cent. 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) 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.

**Global AGR Demand – 1991 to 2008**

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.

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 per cent range. By way of contrast, the replacement rate in Japan is lower, particularly for windscreens, 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 above, long term industry growth in AGR volumes alone is estimated at around 2.9 per cent per annum.

**Specialised Transport**

The Specialised 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 tram, light rail and high speed locomotive)
- Marine
- Electric 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.
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 organisation. The largest players Daimler, Paccar and Volvo have all established operations throughout Europe, North America, South America and Asia. The market has been severely affected by the economic crisis and recovery to 2007 levels is likely to take several years. Long-term, global truck (>3.5 tonnes) is expected to show steady growth particularly in emerging markets.

The Bus and Coach sector, while strongly linked to the Truck sector in terms of chassis and engine supply, is significantly more fragmented. It comprises a few large regional assemblers such as Evobus in Europe and Marcopolo in South America and a large number of smaller companies producing small one-off orders. However, some of the larger European manufacturers such as Volvo Bus 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 characterised 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 one-tenth of the annual truck production volumes but the build rates alone do not truly represent the sector’s worth; the amount of glass in a 12-metre 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 metres 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 need for improved levels of comfort for operator and passengers alike means that the trend for adoption of more value-added glazing applications is expected to continue.

The Off-road Agricultural sector is characterised 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 regional manufacturers such as Caterpillar, JCB and Komatsu. Activity in the off-road agricultural sector has returned to more normal levels after record consumptions of grains and all commodities had driven the prices to all time highs.

The Off-road Construction sector has slowed with the global economic crisis but will return to growth with the market recovery, particularly in emerging markets such as Eastern Europe and Asia where major construction and infrastructure improvement projects are planned.

The pressure to globalise further still exists in these major sectors, but to date progress is most significant in the Truck sector.

The Railway sector comprises a small number of rail transport and rail infrastructure manufacturers such as Alstom Transport, Bombardier, Siemens 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.

The Marine sector covers leisure boats from 5.5 metres up to luxury cruise liners. Leisure boats are manufactured by a small number of regional manufacturers such as Bella Boats, Fiskars, Nimbus and Windy. The demand for leisure boats is more sensitive to global economic conditions and reduced consumer confidence and the short to medium-term prospect is for a flat or slight decline in demand. The demand for luxury cruise liners is expected to be less affected by the current global economic conditions due to the age group and relative wealth of the consumers associated with this market segment.

Most of the major vehicle manufacturers are extending their range to include vehicles from the electric micro car sector. In addition, the sector has is attracted many new entrants to the automotive business. Government incentives for cleaner cities are expected to promote high growth in this area for 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 Specialised 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. PILKINGTON – A LEADING BRAND IN A GROWTH INDUSTRY

3.1 Overview

The NSG Group, which operates under the Pilkington brand in Building Products (BP) 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 28 countries on four continents and sales in around 130 countries. In the fiscal year ended 31 March 2009, the NSG Group reported sales of JPY 739,365 million (approximately euro 5.7 billion). Of the Group’s consolidated sales, 47 per cent were generated in Europe, 28 per cent in Japan, 13 per cent in North America and 12 per cent 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 was de-listed from the London Stock Exchange in June 2006 on becoming a wholly-owned subsidiary of 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.

Flat Glass businesses of the NSG Group

The Flat Glass businesses now account for around 90 per cent of NSG Group sales. In the financial year ended 31 March 2009, Building Products accounted for 48 per cent of Group sales and Automotive for 42 per cent of Group sales.

In Building Products, the largest business is in Europe (accounting for 51 per cent of the business line’s sales). The next largest business is in Japan, with 31 per cent of BP sales, the rest of the world with 10 per cent and North America with 8 per cent of BP sales. In the case of Automotive, Europe is also the largest business, with 51 per cent of the business line’s sales, followed by North America with 21 per cent, Japan with 16 per cent and 12 per cent in the rest of the world.

Flat Glass businesses within the NSG Group
Building Products

Building Products has manufacturing operations in 23 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 exterior and interior applications and glass for the growing solar energy sector.

Automotive Products

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

Employees

At 31 March 2009, the NSG Group had 31,400 permanent employees working worldwide.

Management Structure

The Chairman of the NSG Group is Yozo Izuhara. The President and CEO (Group Chief Executive), responsible for managing the operations of the Group, is Katsuji Fujimoto and the Group Finance Director is Mike Powell.

The worldwide Building Products business is managed by Mark Lyons, with regional BP 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

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 capitalise on the advantages of the best local labour 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 (Asahi), Saint-Gobain and Guardian. The Group is either already established or is developing operations in leading emerging markets, with key target markets identified as China and India.

Strong Market Positions

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 integration has moved the NSG Group to a leading global position in the automotive glass market and, despite the current downturn, the Group is well positioned to meet the overseas production needs of Japanese automakers.

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 operates an extensive network of 49 float lines, giving full coverage of the global market and providing the Group with advantages in terms of strategy, efficiency and effectiveness. As part of the Group’s restructuring programme, float capacity has been reduced to match market demand. Some of the Group’s float lines have been mothballed, with others on temporary hold awaiting the upturn.

NSG Group Global Float Manufacturing Operations
Strategic Direction

The Group’s 10-year strategy, published in July 2006, remains central to its long-term vision and the basic objectives remain in place, although the current downturn in world trade has required some adjustments to the timetable for achieving the Medium-term Plan targets, set for March 2011.

The current operational focus is firmly on achieving the objectives of Phase 1: integrating the business and strengthening competitiveness, improving financial strength and preparing for future growth. In parallel, planning is already underway for Phases 2 and 3 in emerging markets – creating joint ventures and undertaking investment to ready the businesses for expansion in regions such as India and China.

Despite the current economic background, good progress has been made on the Group’s strategic objectives in phase 1 of the 3-phase strategy, with the net debt target of JPY 350 million attained one year ahead of schedule. A new integrated global organization has now been established, with good progress on the realization of synergies. In Phase 2, the intention is to achieve strong growth in the Flat Glass sector, expanding geographically, particularly into emerging markets. In Phase 3, the Group will be exploring new areas for further growth, as well as exploring new businesses by leveraging both its customer base and its technical and operational competencies, in addition to pursuing acquisitions and alliances in adjacent areas.

Restructuring

In the financial year ending 31 March 2009, the Group’s financial results reflected the global slowdown in international trade, with a sharp contrast between the outcomes for the two halves of the year. In the first half, the Group announced that sales and profits were in line with the forecast, with further progress achieved on reducing debt. In the second half, all three of the Group’s business lines were adversely affected by the unprecedented slump in world trade.

In January 2009, the Group announced restructuring initiatives designed to address the economic downturn and to improve profitability going forward. These build on early action taken by management in response to the sudden and rapid changes in the global economic environment. The total investment in the restructuring programme is expected to be around JPY 25 billion.

The overall objective of the programme is to protect the business in the short term and to re-establish profit growth from FY2011 onwards. Good progress has been made in implementing these initiatives, which are designed to reduce capacity and output around the Group to match the requirements of its customers. Under the current restructuring programme the Group is reducing overall headcount by approximately 6,700 people by March 2010. 4,500 of these employees had already left the Group by 31 March 2009.

The restructuring includes management headcount reduction through reorganization, shift reductions and line closures in some plants and temporary and permanent plant closures throughout the Group’s global operations. Preparatory work on growth opportunities in Phases 2 and 3 of the Group’s 3-phase strategy is underway. In FY2010, focus is on implementing the restructuring programme.

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 NSG 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. Partnerships with global players include those with Saint-Gobain in South America. Local alliances, for example Shanghai Yaohua Pilkington and China Glass Holdings in China, complement the portfolio.
Technical Leadership

Before the acquisition, the Pilkington/NSG relationship had centred on a cooperation agreement between the two companies’ automotive R&D activities, enabling joint automotive technology development and implementation. Both companies were founded on technological innovation in Flat Glass and the NSG Group intends to invest in sustaining this technology to create shareholder value and to be technological leader in the global glass industry. Pilkington played a key role in the industry’s technological advances in the 20th century, including Sir Alastair Pilkington’s invention of the Float Process, announced in 1959. Today, the NSG Group’s technical and manufacturing resources are well integrated into global programmes that identify and respond to market needs and increase the efficiency of production.

The technology function has been developed to meet the needs of the building and automotive products business lines, ensuring that each has access to its unique technologies as well as those (such as glass composition and coating) which are common to both. Each business line operates a globally managed R&D programme and there are strong links between the two. The NSG Group is thus able to prioritise objectives on a global basis and rationalise its resources to remain cost efficient while maintaining its responsiveness to the need for cost reductions and new products.

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, on-line coating and complex shaping technology, especially for automotive windscreens and backlights. The Group invested around JPY 10,500 million (approximately euro 80 million) in research and development in FY2008. The NSG Group owns or controls approximately 5,000 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 licence to patents held by third parties. The Group has also been active in selective licensing of its patents and technology, in the areas of on-line coating, encapsulation (of automotive glazing) and rain sensors (for automotive glazing).

1This centred on the idea of forming a ribbon of glass by 'floating' the melted raw materials at high temperature over a bath of molten tin. The float glass process eventually replaced the twin grinding and polishing process for making plate glass to become the universal process for the manufacture of high quality glass. See Appendix 1 for more details.
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 windscreens in complex shapes to fine tolerances.
- Pilkington Pyrostop™ advanced fire-resistant glass.
- EZ-KOOL®, 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.
- Pilkington TEC™ range of glass for Thin Film Solar and Pilkington Sunplus™ for the C-Si Solar sector.

Competitiveness

The NSG Group operates in two of the most competitive markets in the world; float glass production and automotive component supply, and is well aware of the commitment and effort needed to stay ahead. The delivered cost of float glass is fundamental to success and management intend to take every opportunity to reduce costs further. To consolidate the Group’s position as the lowest cost producer of float, and to remain competitive in Automotive, the Group aims to achieve a continuous reduction in its cost base. The overall objective of the current restructuring programme is to protect the business in the short term and to re-establish profit growth from FY2011 onwards. Good progress has been made in implementing these initiatives, which are designed to reduce capacity and output around the Group to match the requirements of the Group’s customers.

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.

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 Specialised 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 windscreen line was launched in Italy.
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 per cent of the energy consumed in developed countries. 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 Labelling 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 maximise 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 last year under the Pilkington energiKare™ brand, offering home owners the opportunity to improve the efficiency of their windows by up to 90 per cent.

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 has been constructed at Vizag in southern India 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. This is operated by a 50:50 joint venture between the NSG Group and China Glass Holdings (CGH).

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.

CGH completed the acquisition of Blue Star Glass and Beijing Glass in early 2007, bringing the number of floats managed to 12. Shortly after this, the NSG Group increased its stake in CGH to 30 per cent.

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.

Proactive use of e-Commerce

The Group has been active in developing a platform to exploit e-Commerce, particularly in the business-to-business (B2B) sector. It has developed and introduced e-Commerce solutions that are both standardised and tailored to local languages and business methods. Most customers and suppliers in the Building Products and Automotive businesses are now able to do business online.
3.3 Building Products Overview

Building Products (BP) represented 48 per cent of the NSG Group’s revenue in FY2008/2009. BP’s operations are organised into six businesses; Building Products Europe, Building Products Japan, Building Products North America, Building Products South America, Building Products China and Building Products South East Asia.

Float glass for the building market is 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 specialised applications. Large-scale coating, laminating, and silvering processes are used to make these products. BP has float glass manufacturing or processing operations in the following 20 countries; Argentina, Austria, Brazil, Chile, China, Czech Republic, Denmark, Finland, Germany, Italy, Japan, Malaysia, Netherlands, Norway, Poland, Russia, Sweden, United Kingdom, United States and Vietnam. The Group’s BP business in Switzerland was sold to Flachglas Wernberg GmbH (in which the NSG Group has a 49 per cent stake) in July 2009.

BP’s main activities include:

- Float manufacturing: 0.4 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, merchanting, fire protection
- Glazing systems: e.g. Pilkington Planar™ (frameless glazing system).
- Products for the Solar Energy sector

Product Range & Brands

Pilkington branded 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 minimise 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.

Given the variety of building designs and climatic conditions and the different levels of exposure to solar radiation during the year, the choice of glass must be able to protect the inside of the building to ensure maximum comfort, minimise energy consumption, guarantee safety and, not least, provide the optical and aesthetic qualities that satisfy the designer. Pilkington is continually innovating and developing products that satisfy the full range of architectural requirements. Pilkington’s 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™;
- To low-performance, body-tinted glass in the Pilkington Optifloat™ Tint range;
- And even to solar control glass combined with the revolutionary, self-cleaning Pilkington Activ™.

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

**Thermal Insulation**

Advances in low-e glass technology have made windows an essential contributor to energy conservation and comfort, minimising 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.

Pilkington’s low-emissivity range covers all levels of requirements:

- From on-line products such as Pilkington K Glass™;
- To extremely low $U_g$-value off-line solutions in the Pilkington Optitherm™ range;
- Through to Pilkington Suncool™ 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™ is available in laminated form for additional safety performance. It 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. Pilkington Spacia™ may even allow the use of the original frames. Already successful in Japan, sales are developing worldwide, particularly within historic buildings.

Pilkington energiKare™ is a family of energy efficient Insulating Glass Units innovatively using low iron float glass Pilkington Optiwhite™ in combination with Pilkington K Glass™, to provide the best possible energy efficient performance. Sales are now developing in the UK where this exceptional combination of thermal insulation and passive solar gain helps domestic window companies meet homeowner demand for more energy efficient windows. The product is being used in both replacement windows for homes and in newly built dwellings utilising both double and advanced triple glazing technology.

**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 employs three product lines and technologies to protect people and property against fire - Pilkington Pyroshield™ (wired glass), Pilkington Pyroclear® (basic integrity with the superior edge system), and Pilkington Pyrostop® and Pilkington Pyrodur® (a special proprietary clear intumescent interlayer technology). The range of transparent interlayer products is the global market leader in high performance fire-resistant glazing, combining additional functional 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, the Pilkington range of fire-resistant glasses is 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 topic. It is not a question of it being a luxury anymore 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 (Poly Vinyl Butyral) 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 large variety of product combinations, Pilkington Optiphon™ offers the opportunity to achieve specific noise reduction requirements.

Pilkington Activ™ self-cleaning glass represents both a significant technological breakthrough and an important marketing development.
Safety and Security

Innovations in the development of safety and security glasses have opened up new avenues of design, allowing both 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 is also able to withstand deliberate attack of various kinds (physical or armed). 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 which stipulates 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 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 three times that of ordinary glass).

Pilkington Optilam™ is a laminated glass that provides both impact resistance and security since it may break on impact, but the glass is held in place thus preventing injury or intrusion. The performance of Pilkington Optilam™ can be varied by changing the number and thickness of glass panes and interlayers in combination.

Self-Cleaning Glass

Pilkington Activ™ is the world’s first self-cleaning glass. Its unique dual-action 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: using daylight to break down organic dirt and then rain to wash away any loosened dirt.

Pilkington Activ™ also dries off faster, leaving the glass cleaner and with reduced streaks. This provides clear views and makes it ideal for various applications, from building façades to conservatories.

Pilkington Activ™ is an on-line coated product and therefore can 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™ Blue and Pilkington Activ™ Neutral are coloured tinted glass combined with Pilkington Activ™ coating and are perfect for use in conservatories and glass roof structures.

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™ 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.

The Pilkington Texture (Patterned) Glass offers privacy and style throughout the home. The range is continually updated to introduce new and exciting patterns.

Pilkington Screen Printed Glass is a clear or tinted float glass, which has been printed with ceramic ink designs and subsequently toughened, a process which also fires ceramic paint into the glass surface.

Pilkington Screen Printed Glass is available in wide range of colours and designs that fully or partially cover the surface of the glass.

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 Enamelled, Pilkington Spandrel Glass Silicon and Pilkington Spandrel Glass Coated.
High quality Pilkington Optimirror™ is produced using the latest environmentally friendly processes and materials. This is now available in a safety-backed version in the Pilkington Optimirror™ Protect range.

**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 include the range of solar control products, low-emissivity glass, screen-printed glass and Pilkington Activ™ self-cleaning glass.

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

**Special Applications**

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

- Pilkington Optiwhite™ is a specially developed float glass, which displays none of the slight green tint apparent in most standard glasses, making it suitable for a wide range of applications from commercial façades for prestigious building projects to furniture. Its high light transmission makes it ideal when producing thick laminates which would otherwise attenuate much of the incident light.

- Pilkington OptiView™ is an anti-reflective glass, which is ideal for a wide range of traditional and new applications, including museum displays, retail shop fronts and showrooms.

- Pilkington Microfloat™ is extremely thin, high-grade float glasses 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.

- Pilkington Mirropane™ is a coated glass product 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**

The Group is well placed to supply products for all three of the leading technologies in the growing Solar Energy sectors: Crystalline PV, Thin Film PV and Concentrated Solar Power, in which contribution to solar system performance is paramount.

Pilkington Optiwhite™ is an ultra-clear float glass with very low iron content and its high solar energy transmittance makes it ideal for Concentrated Solar Power applications and PV module cover plates. Additionally, it can also be used as a substrate for off-line transparent conductive coating (TCO) deposition.

Pilkington TEC Glass™ 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, both Silicon and Cadmium Telluride based. Pilkington Sunplus™ is a high performance, low iron glass designed to maximise 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.
Building Product Businesses

Building Products Europe (BPE) is the NSG Group’s largest single business. The main Upstream production facilities are in Finland, Germany, Italy, Poland, Russia, Sweden and the UK.

Europe – Primary Production Facilities

The Downstream part of the business includes all of the glass processing and wholesaling operations serving the European market through a network of forty-nine 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 merchanting, the manufacture of safety glass, and the complete range of (Pilkington Insulight™) glass units.

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 the employees.

Europe: Distribution of “Downstream” Operations
Building Products Japan

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

The downstream business, represented mainly by offline coating, insulating glass, laminated glass, tempered glass, fire protection glass and vacuum glazing glass production, operates across 18 different sites across the country. Japan is also the only location where the NSG Group manufactures Spacia – the world’s first commercialised vacuum glazing product.

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

Building Products South East Asia

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.

South East Asia - Production Facilities
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 (12 float lines).

SYP’s two Shanghai float lines were closed in December 2008, but replacement lines are under construction in nearby Changshu. In addition NSG Group itself operates a float in Changshu, in a 50:50 JV with SYP. It is currently installing advanced on-line coating which will enable it to respond to the rapidly growing, regulation-driven market for value-added low-e glass.

The NSG Group operates a further rolled line in a 50:50 JV with CGH. This produces low-iron glass cover plates for the Solar Energy sector.

Building Products North America (BPNA)

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.

In addition to sales offices and float glass plants across the country, the business also has a Technical Services Department committed to working with customers to answer any glass-related technical and performance questions. BPNA has four float lines across the USA, in California (Lathrop), Illinois (Ottawa), and two in North Carolina (Laurinburg).
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 facility in Colombia. There is only one other float glass manufacturer in South America, namely Guardian with one line in Venezuela and two in Brazil. The NSG Group and Saint-Gobain together operate four lines in Brazil and The NSG Group operates one in Argentina and one in Chile. The Group also has warehousing activities in Colombia, Venezuela, 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.

South America - Production Facilities

Cebrase (50% JV with Saint-Gobain) 4 Floats in Brazil

Lirquen

Jacarei Caçapava Barra Velha

Lavallol

NSG Group and Saint-Gobain together operate four lines in Brazil and the NSG Group operates one in Argentina and one in Chile.
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 supplier of automotive glazing products.

In serving this market, Pilkington Automotive operates a global key account network, matched to the individual VM’s own organisational requirements. Within the automotive glazing industry, Pilkington led the way in globalising 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; 43 locations in total in 19 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 globalisation. 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 organisation enables optimisation 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 network throughout NAFTA (120 wholesale locations) and both Western and Eastern Europe (75 service facilities). It also serves the aftermarkets in Japan, South America, China and South East Asia.
**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, including Toyota, GM, Ford, VW, Renault/Nissan, Chrysler, Mercedes, Fiat, Honda, PSA, BMW, Tata, Hyundai, Mitsubishi, Subaru, Isuzu and Suzuki, together with their respective subsidiary brands. 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 manufacturers.

**Specialised Transport**

Pilkington Automotive provides high quality glazing solutions and value-added products to the Original Equipment manufacturers of specialised 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 recognised as world leading manufacturers, with many operating on a global basis.

**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 per cent. It is also well established in serving the aftermarkets in Japan, South America and South East Asia.

**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 standardisation 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.

Utilising its global R&D and global account management structure, Pilkington Automotive’s market-focused approach to 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 recognised 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. With a truly global simulation team, our capabilities continue to improve, forging the link between simulated results and manufactured products.

Pilkington Automotive’s computer simulation centre team predicts the optical properties of a particular shape of windscreen, 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 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 with what happens in practice 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 stretching manufacturing processes to their limits. Pilkington Automotive maintains an extensive programme of process development to keep abreast of the latest design trends. For instance, new styling requirements for windscreens 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 inspection techniques, capable of analysing 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.

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 moulding, provides a modular glass assembly with a multifunctional gasket around the rim of the glass, utilising injection-moulding technology. This gasket can provide many features from a single moulding 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 20 years 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, minimising 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 colour of infrared reflective windscreens.

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™, EZ-KOOL® and UV Cut are green, optimised 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 per cent 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.

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 per cent 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 per cent in comparison to an optimised green glass used in the front of the vehicle. It also prevents more than 95 per cent 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.

Sundym™ and the Legart range are a suite of neutralised green privacy glasses that blends with the green front door glass to allow both a design choice and an improvement to solar loading. The Sundym™ glass has a light transmission in the range 26-45 per cent over a 3-5 mm glass thickness range. In a vehicle equipped with Sundym™, the heat entering the rear of the vehicle is reduced by 45 per cent 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 windscreen product that reflects more than 30 per cent 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 also offers a solar-reflective product, Pilkington Siglasol™ utilising infrared 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 minimised, 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. Over the next ten years it is expected that as new car models are introduced, the type of glazings used in the side windows (sidelights) of cars will move from toughened glass to laminated glass. The trend to fit laminated sidelights started in Europe, but there is now global interest with US and 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 and reduction in theft from cars

Comfort
- Solar control improvement
- Reduction in extraneous noise
- Greater than 95 per cent 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 2.1/0.76/2.1mm, 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, colours, acoustic enhancement).

The additional cost of laminated side glazings is offset by the above opportunities which can enable the car manufacturer to customise 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 pace-setter 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 modified 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 windscreens 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 windscreens 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 windscreens 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 windscreen.

Pilkington Automotive has also developed a full area coated heated windscreen that provides both de-ice and anti-mist properties. As power levels increase in vehicles, this will provide an elegant way to electrically heat windscreensthat have an infrared reflective coating applied directly to the glass. This heating functionality is in addition to the benefits of optimised 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 windscreen and automatically activates the windscreen wipers. This rain sensor, attached to the interior of the windscreen, 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 JIT 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 windscreen fitters, thereby supplying them with all the equipment required for a reglazing job.
3.5 Social Responsibility

The NSG Group and the Environment

The Group takes its environmental responsibilities extremely seriously. All operations are required to meet all legislative standards as a minimum, and where local requirements are not considered sufficient to address an issue, the Group’s corporate standards do. The Group’s products make important contributions to people’s wellbeing, their quality of life and to the conservation of energy worldwide. Significant effort continues to be directed towards improving environmental performance and ensuring that quality products are manufactured that have a positive impact on the environment.

The Group’s Environmental Policy defines its approach on environmental matters, outlining its management of current activity, the legacy of past and inherited liability. It reinforces the Group’s commitment to using good scientific principles to try to predict and assess its impacts on the environment both positive and negative. The Group acknowledges that its activities will inevitably have an impact, but has taken steps to minimise the adverse nature of any impact and has put in place systems to try to ensure that it manages such impacts in a controlled manner. Principal amongst the tools used is the Group’s environmental management system, certified to ISO 14001 for all its glass manufacturing and automotive manufacturing sites.

The Group has increasingly recognised that the environment is only one part of a wider sustainability agenda. Care and respect for the environment must go hand in hand with the social and economic needs of society. A new NSG Group Sustainability Policy will now sit above and be complemented by its environmental policy. The Sustainability Policy draws together a number of policy issues and codes of conduct governing the Group’s relationship with all its stakeholders (workforce, customers, suppliers, investors and shareholders and of course neighbours and communities). The policy emphasises the life cycle aspects of the Group’s products and their use and its commitment to working with those who share the Group’s philosophy in this area.

The Group is committed to reporting on its performance both good and bad. To this end, it decided to use calendar year 2007 as a starting point for reporting on the progress of the Group. In the past, both NSG and Pilkington reported on environmental and safety performance, but with considerable differences in some of the parameters used. Additionally, both parts of the company have undergone considerable restructuring following the acquisition of Pilkington by NSG. Direct historical comparison is therefore difficult and it was felt more useful to allow the past reports to remain on their own merits but to build a new reporting structure based on the current business and geographic structure of the NSG Group.

Environmental and safety performance data is now collected right across the Group using an online electronic data reporting system known as Airsweb™. This database is multilingual and accessed over the corporate intranet. All sites are connected to the system either directly or via VPN allowing monthly updating of relevant information. Environmental data is collected under the broad headings of energy, emissions to air, water usage, emissions to water, recycling and waste. The data collected is based primarily on the core environmental performance indicator set of the Global Reporting Initiative (GRI). In addition to the collection of environmental emissions and resource usage data the Airsweb™ system also incorporates an incident reporting system.

The NSG Group continues to work with regulatory authorities worldwide on issues relating to historical industrial activity on and around Group premises. The safety of neighbours and employees and the protection of the environment remain of paramount concern.
Health & Safety

The health, safety and wellbeing of all employees, contractors, visitors, neighbours and customers remain at the forefront of all business activity. While all individuals have a responsibility for their own health and safety and that of their colleagues, ultimate responsibility for health, safety and the environment rests with the Group CEO. Safety programmes continue to emphasise the importance of improving behaviour and of individuals taking personal responsibility. Changing the culture in this way builds on the safety management systems already in place, giving everyone a greater degree of safety, not just at work but also beyond. All injuries at work are regarded as unnecessary and avoidable. No matter how minor, each one must be reported and investigated. Only by investigating and learning from such incidents will the desired levels of safety performance be achieved.

Safety performance in the Group is measured using two key performance indicators.

1. The Lost Time Injury Rate (LTIR) records work-related accidents or illnesses preventing individuals involved being able to report for work on the following day or shift. These are expressed as a rate per 200,000 hours (approximately the time worked by 100 people in one year). The LTIR was 0.25 in FY2009: an improvement of 14 percent. As the LTIR has improved, it has become less useful as an indicator of performance and the Significant Injury Rate (SIR) is now the Group’s primary indicator.

2. The Significant Injury Rate (SIR) is now the Group’s primary indicator records injuries requiring medical treatment or the reallocation of duties to allow an individual to continue working. The SIR was 0.9 in FY2009; an improvement of 28 percent.

There were 111 lost time injuries and 294 injuries classified as significant in the year, for the total 32,500 Group employees (this total has since been reduced through the restructuring programme to around 31,400 permanent employees). A fatal accident involving a contractor occurred at the Group’s site in Concepción, Chile, in September 2009. A proactive safety evaluation system, now renamed PRISM, exists in all facilities, ensuring that all activities are subjected to risk assessment, with proper procedures in place to protect individuals. Sites have continued to make measurable improvements in their proactive safety performance. Behavioural safety programmes have been promoted together with further development of ‘Key Safe Behaviours’ and the ‘Stop and Think’ safety guides. The percentage of safe and unsafe behaviours measured by these programmes is carefully monitored, which complementing the ‘incident reporting’ already established.

Working with contractors on existing plants and new construction sites presents major safety challenges Group Engineering and local experts, working closely with principal and sub-contractors, has actively driven the new contractor safety training programme introduced in 2006. The project aims to raise safety awareness and encourage safe working, and this remains an area of special focus. The Group has continued close collaboration with other parts of the glass industry and beyond, to improve safety.
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 crystallisation, i.e., the molecules cannot arrange themselves into a crystalline pattern. The fast rate of cooling to prevent crystallisation 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 per cent 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 per cent 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 colour 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 per cent 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 per cent of the batch weight but about 60 per cent of the batch cost. In terms of costs, raw materials and energy are the single largest elements, followed by overheads and prime labour.

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 85 per cent 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 8 per cent 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.

Float Glass Raw Materials and Nominal Costs
3. The Float Process

At the heart of the world’s glass industry is the float glass process. Invented by Sir Alastair Pilkington and announced in 1959, the process 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 kilometres of glass a year in thicknesses of 0.4 mm to 25 mm and in widths up to 3 metres. 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 vapour 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.
Appendix 1 – Glass Manufacture

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.

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.

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 650ºC, 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 500ºC and 600ºC 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.
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 moulding 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 moulding 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.
## NSG GROUP AND ASSOCIATES’ GLOBAL FLOAT OPERATIONS

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As at August 2009