"Silica sand supply and demand in the Asia-Pacific glass market".

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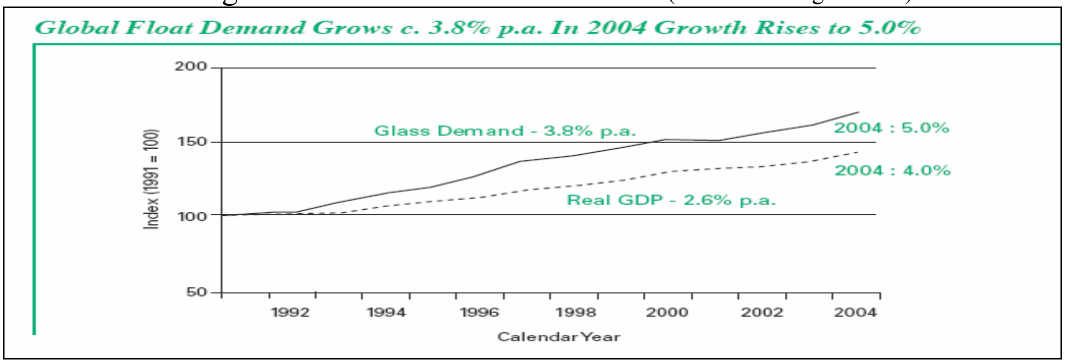
It is said that human beings first created glass in 5,000 B.C. So we have been living with glass as long as 7,000 years. We take glass very much for granted, but it is an incredibly useful product from use in windows to the most modern electronic devices such as digital cameras. Current world production of glass is estimated at 140-150 Mt per year. The Asia-Pacific region produces and consumes around one third of this amount, i.e. approximately 45 MT. As a general rule Japan and China together account for more than 70% of most markets, a formidable pair in the region.

Glassmaking is a major sector which needs consistent, correctly sized and low iron silica sand. Silica sand is the major raw material used in glassmaking, comprising some 70 by volume of raw material but far less than that in value. Glass manufacturers usually classify silica sand into separate groups on the basis of chemical and physical properties. Since the impurities of silica sand in different deposits around the region are dependant on numerous geological factors, glass producers have set specifications to each source of approved material and in general, manufacturers are concerned mostly about the consistency of the approved material on a day-to-day basis. Minerals such as chromite, picotite, ilmenite, leucoxene, kyanite and zircon are minerals on which strict limits are placed for glass raw material. Because of their refractory nature, such minerals either do not melt or only partially melt which results in stones or feathers in finished glass. These create stress concentration points which lead to potential fracture.

Floating Process

This is an innovative flat glass production process invented by Pilkington of the United Kingdom. Utilizing the specific gravity difference between glass and molten tin.Aas glass is lighter than molten tin, it flows over the molten tin and glass itself is molten in a furnace and the finished glass is pulled out by crimp rollers without any strain after the annealing process.This type of glass can even be used for mirrors as is. These days, this process is used through out the world.

Figure 1. Global Flat Glass Demand (Source: Pilkington PLC)



World demand for flat glass will rose more than 4 percent per year to nearly 4 billion square metres in 2004, with a market value of over US$40 billion. Based on the current proportion of glass manufactured and used in Asia the value in this region would be around US$13 billion. In addition to this very large figure are all the container glass, tableware, cathode ray tubes and various specialty glass including thin film transistor glass used in the modern thin plasma /LCD TV and computer monitors. Asia is said to produce in excess of 75% of all TV and computer monitors today. Demand for raw flat glass reached almost 40 million metric tons in 2004, where 72% of the final glass weight being silica.

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Table 1. Estimated Flat Glass Demand

Sector	World Demand	Asian Region Demand	Asian Region Demand %
Construction	2,515	830	33
Motor Vehicles	738	280	38
Specialty Markets	657	289	44*
Total	3,910	1,399	35.7

* Due to large share of TV & Computer monitors Source: Adapted from Freedonia Review

Asia is continuing strong annual gains, due largely to sustained expansion in China. Long-term prospects remain favourable, based on the region's pressing need for adequate new housing, industrial expansion, and rising motor vehicle production. Over the long-term, glass demand is growing at 4 to 5 per cent p.a., significantly above global economic growth rates. Capacity utilisation is expected to remain above 85 per cent over the coming years. Demand growth for glass is driven not only by economic growth, but also by legislation and regulations in response to the growing need for energy conservation. Demand for value-added products is growing more quickly than for basic glass, enriching the product mix and boosting the sales line of the building products industry. Value-added products are also becoming increasingly important in the automotive market, delivering greater functionality to a vehicle's glazing and adding a further growth dimension to automotive glazing sales. A proportion of the high quality float glass, and indeed some of the rolled, is further processed by laminating, toughening, coating and silvering and some of this ends up in the form of insulating glass units or automotive windscreens and sidelights. Glass manufactured in flat sheets (float, sheet and rolled) which may be further processed. On average 1 tonne is approximately 125 sq.m. The global market for float/sheet glass (excluding rolled glass) is approximately 30 million tonnes p.a. This is dominated by Europe, China and North America, which together account for over 70 per cent of demand. China is increasing in its global importance as with many other products including steel and cement, all driven by strong economic growth.

Container Glass Manufacturing Process

Apart from the flat glass motioned above, the other dominant user of silica sand is glass containers, many of which are bottles. Huge changes in this sector have been occurring during the past decade including the "light-weighting" of bottles, lead by Japan, and the increased use of cullet brought about by new colour sorting equipment, again lead by Japan. A brief summary of the main processes involved in making container glass follows.

BATCHING PLANT

Commercial glass is made by melting predominently silica sand, soda ash and limestone. Secondary ingredients (carbon, red iron oxide, chromite etc are added to control colour, provide ultra-violet protection and enhance the working properties of the molten glass. As much as possible cullet is included in the batch. Many glass container plants in the region now include the latest computerised control technology. Raw materials are stored in silos from which they are automatically weighed out from computerised control rooms and transported to batch mixers according to pre-programmed recipes. The mixed material (or batch) is then transported to the holding bin at the furnace.

MELTING

From the holding bin, the batch is continuously fed to the furnace where it is converted to molten glass and maintained at temperatures up to 1500ºC. Molten glass is continuously withdrawn through a submerged throat where it proceeds to the refiner area of the furnace and cooled to approximately 1200ºC, before being delivered to the individual bottle-making machines via the forehearths. The furnaces are fully computerised and critical parameters are controlled to very close tolerances. Most glass plants in the region are now some of the most modern in the world with a productive life span (known as a campaign) of +10 years whilst, at the same time, allowing finer temperature control resulting in improved productivity and quality.

FORMING

The molten glass enters the feeder to the bottle-making machine where the streams of glass are cut into pieces of a pre-determined weight, called gobs, each required to make a single bottle. The gobs of molten glass are then individually fed into the moulds of the bottle-making machine. The bottle is formed in two stages. Firstly, the gob of glass falls into a blank mould to produce a parison. Here the finish (neck) of the bottle is formed and a long narrow cavity is blown within the centre of the parison. All blowing is done by means of compressed air. The parison is transferred to the main mould where the bottle is given its final shape. Air is forced under pressure into the hollow cavity to expand the glass to its final shape inside the mould. The newly formed bottle is coated with a thin layer of tin oxide to strengthen it before entering the annealing lehr. In the lehr, the bottle is cooled from 560°C to 100°C in a controlled manner to remove the stresses caused by uneven cooling and to ensure the bottle is stable and safe to handle.

Modern treatments to the formed containers include:

HOT END COATING Tin oxide added for scuff resistance and prepares the glass surface for cold-end coating.

FREON APPLICATION For bloom prevention

LEHR FURNACE An annealing process reducing temperature in a controlled manner from 560°C to 120°C. This gradual cooling down remove stresses and makes a strong product.

COLD END SPRAY Involves a polyethylene wax between the rows providing lubricity for ware handling of container

PALLETISING Automatic packaging of glass at high speeds Automatic empty pallet and full pallet delivery via shuttle car Plastic shrouding of pallets for storage and transportation of glass to the customers.

Float Glass Production Processes

Colburn Process

Nihon Sheet Glass Co. used to produce sheet glasses by means of Colburn process since sheet glass can be pulled out horizontally which allows having a longer gradual cooling span for producing soft and sticky glass sheets.

Fourcourt Process

Asahi Glass Co. used to produce sheet glasses by this process. Since it pulls out the sheet glass vertically in a tall building, but the cooling process span is short and sheet glass becomes very solid and fragile. Its advantage over the other processes is to be capable of providing a plural number of glass pulling-out gates from a melting chamber. Although these two processes enabled to produce flat surface sheet glasses in certain extent, buffing processes were necessary for mirrors. Still some of foreign manufacturers are using these processes.

Floating Process

It is an innovative flat glass production process invented by Pilkington of the U.K.

Utilizing the specific gravity difference between glass and molten tin as glass is lighter than molten tin, glass flows over the molten tin and glass itself is molten by a burner and the finished glass can be pulled out without any strain which can be used for mirror as is. In these days, this process is used through out the world.

Other Manufacturing Processes of Special Type Glasses

The Fusion Process

The fusion, if translated into Japanese, is to indicate something molten, but this process enables to produce sheet glass by not touching impurities contained in the material of a melting chamber. Therefore the products are maintained at very high physical reliability. Its major usage is for liquid crystal displays. Especially, it is most suitable for colour liquid crystal displays (Colour LCD). In 1991, Corning Glass Works of the United States began to sell its products in Japan and is covering majority of market demands. The Nippon Sheet Glass Co. has been in development with Hoya Glass Co. and are supplying prototypes named Corning 7059NH.

Down Draw Process

This process is good for volume production of thin glasses. Asahi Glass Co. is well known as a supplier of a 0.05mm thick glass used for the cover of solar battery. We are supplying a 0.2 mm thick cover glass for touch panel which is also produced by this process. Manufacturers who can supply this type of glasses are Corning Glass Works of the United States, DESAG, a division of Shott of Germany and Asahi Glass Co. of Japan. This type of glass is used for medical inspection, cover glass of microscope and touch panel for the displays

Re-draw Process

This process is a secondary processing rather than a production process. The Down Load process referred to in the above requires highly advanced techniques as well as sophisticated facilities; therefore, this process features to pull out horizontally thicker glasses of 1.0 mm to 2.0mm by giving heat. Nippon Electric Glass Company's continuous re-draw process is one of the most sophisticated production facilities in Japan. It is capable of producing 0.1, 0.2, 03 mm thick glass sheets, etc. Use of such thin glass sheets are for Liquid Crystal Displays and Touch Panels.
Engineers in the field of electronics components are really interested in these glasses for more use

Silica is the most important oxide and constitutes the most tonnage of all the glass making raw materials. Glassmakers depend on a relatively small number of sources. Silica is abundant but glass grade material is relatively scarce. Optical and specialty glasses require even more pure materials that are scarcer. Quartz sand supplies most of the silica to the glass batch. Glass grade sand deposits occur throughout Asia-Pacific with Australia, Vietnam, Malaysia and Indonesia perhaps the largest producing countries. Thailand has good glass sand reserves but the location is adjacent to tourist areas in Rayong and new resources will be needed in the foreseeable future. Cambodia and Vietnam have the closest resources but Australia is another likely source.

TFT-LCD Glass

All of the world’s top-four glass-substrate makers have set up production plants in Taiwan to cash in on the booming thin film transistor-liquid crystal display (TFT-LCD) panel manufacturing business, including Corning Inc. of the United States as well as Asahi Glass Co. (AGC), NH Techno Co. (NHT) and Nippon Electric Glass Co. Ltd. (NEG) of Japan.
AFT in Taiwan now has a annual capacity of 14 million square meters, which are supplied to local TFT-LCD panel makers Chi Mei Optoelectronics Corp. (CMO), AU Optronics Corp. (AUO), Chungwha Picture Tubes, Ltd. (CPT) of Taiwan and Hitachi, Sanyo and Mitsubishi of Japan.

SAINT-GOBAIN ENTERS THE PDP GLASS MARKET

Saint-Gobain’s Flat Glass Sector (Saint-Gobain Vitrage) has decided to expand into the booming glass market for flat TV panels, through the production of glass for PDP (Plasma Display Panel). This technology aims at top-of-the-range large dimension screens. PDP Glass will be manufactured by DISPLAY GLASS ALLIANCE, a joint-venture created to this effect between Saint-

Gobain Vitrage (which owns 30 %), the Japanese glassmaker Central Glass (40 %) - which already partners Saint-Gobain Vitrage in the manufacture of Automotive Glass in Japan - and the Korean glassmaker Hankuk Glass Industries (Hanglas) (30 %) of which Saint-Gobain Vitrage is the majority shareholder. The joint venture's first processing plant will be built on the Ochang site, located 100 km from Seoul (Korea). The primary float glass to be processed will initially come from a Central Glass facility located in Ube (Japan), and subsequently from a specialized facility located in Korea. Production should begin in early 2006. By combining the skills and know-how of Central Glass, HGI and Saint-Gobain, the joint venture will be able to leverage the technologies, products and customer base that should ensure its technical, commercial success.

Silica for this type of specialty or mother glass needs to be very low in impurities especially Fe_2O_3 and Na_2O. Very few sources are suitable for this. Index Minerals in Tasmania is a supplier, and a new project known as Maydena Silica Sands also in Tasmania is developing a project. Unusually pure natural silica is the key. Some quartz from India and Sri Lanka have been used in the past. Undoubtedly China has deposits which if developed would likely supply domestic demand when that time comes.

Physical Characteristics of silica sand for glass

The physical specifications deal exclusively with particle size. The grain size of batch materials strongly affects the amount of energy required for melting. Glass makers prefer a near uniform size to the batch ingredients to insure efficient melting; they typically use material whose grains range from 0.59 to 0.149 mm. However, in textile and reinforcing fibre glass more than 90% of the raw material grains are smaller than 0.045 mm (45 µm). There is consideration to tighten these limits from 0.3 to 0.1 mm, especially for sand since it is the most difficult component to melt. Grain shape of the sand also affects melting. Angular grains offer more surface area and faster melting than rounded grains. Likewise, frosted or pitted grains offer an increase in surface area that can enhance melting. Uniform size among all of the ingredients also speeds melting, minimizes segregation during the batch handling, and homogenizes the melt. If very much of the batch is coarser than the specified range, incomplete melting often occurs, which results in a poor quality product. If very much of the batch is finer, dusting occurs which creates housekeeping problems outside the furnace. Inside the furnace fines can harm the furnace refractories and heat exchangers.

Processing to remove impurities

Refractory heavy minerals (RHM) represent the raw material impurity most avoided in most glass compositions. RHM include kyanite–sillimanite–andalusite, zircon, corundum, chrome and other spinels, rutile–leucoxene, and staurolite. These minerals do not melt in most glass compositions at normal glass making temperatures and end up, unmelted, in the finished product as a solid inclusion or stone defect. Specifications for RHM usually relate to particle size and quantity. Particles larger than 0.25 mm are the greatest concern and the quantity may be specified either as a weight percent or on a particle count basis.

Sizing

Size segregation represents a major processing function. Each glass maker may have slightly different requirements for their gradation, but generally they want raw materials to range from 0.59 to 0.149 mm. After processing to remove impurities and classifying the product to its proper size range, the final step is drying. Glass producers generally want the raw materials to contain less than 0.1% moisture.

Logistics

Like most industrial minerals, transportation costs can exceed the FOB price of the raw material. Most glass plants demand frequent deliveries because melting and production takes place around the clock. They must add batch every day and they lack storage for large quantities of raw materials. For imported silica sand, stockpiles need to be maintained at both ends of the shipping route to eliminate the possibility of running out of this key raw material, which is immensely inconvenient and costly for all concerned.

Table 2 Typical Glass-Grade Silica Chemical Content

Compound	Flat Glass	Container Glass
SiO_2	≥99.5%	≥99.5%
Fe_2O_3	≤0.04%	≤0.03%
Al_2O_3	≤0.3%	±0.01%
TiO_2	≤0.1%	≤0.03%
Cr_2O_3	≤2 ppm	≤10 ppm
CO_3O_4	≤2 ppm	
MnO_2	≤20 ppm	
CaO-MgO		±0.1%
ZrO_2		≤0.01%
Na_2O-K_2O		±0.1%
Moisture		≤0.1%

Figure 2. Taiwan Glass Operations

Taiwan Glass has expanded into China and has operations producing fibreglass, flat glass and container glass on both sides of the strait.

Fibre Glass

There are three categories of fibre glass; insulation (glass wool), reinforcement, and optical. Most fibreglass manufacturers produce both glass wool and reinforcing fibreglass. Optical fibres are a specialty and require more sophisticated production methods and very special glass compositions and high purity raw materials.

Flat Glass

Within this category, 57% of the product goes to the construction industry, 25% to the automotive industry, and the remainder goes for such products as mirrors, solar panels, store displays, furniture, and advertising signs. Pilkington PLC of the United Kingdom bought LOF in 1986 and Nippon Sheet Glass bought 20% of LOF in 1989.

Specialty Glass
Specialty glass only makes up 1 to 2% of the total glass produced but accounts for 15 to 16% of the value. Included among these specialty products are tumblers, table ware, lead crystal, scientific and laboratory ware, glass tubing, TV glass, cookware, pharmaceutical, optical glass, ophthalmic glass, lasers, optical waveguides, glass ceramics, lighting glass, fibre optics, glass spheres, and numerous others.

Technology
Technological advances have come in both the mineral processing industry and the glass manufacturing industry. As easy to mine and high purity deposits were depleted, the raw material supplier has had to improvise and beneficiate to meet the glass makers' requirements. Likewise, the glass maker found ways to improve old products and develop new ones. Higher speed manufacturing processes for glass products usually has meant changes in the raw material specifications: smaller grain size distributions to give faster melting, plus considerations about grain shape, and tolerance limits for impurities. Specifications can never be static for glass making raw materials. *The glassmaker must find the best available raw materials at the lowest possible delivered cost to make a competitive product.*

Specifications
The production of glass articles results from a continuous process and any error in raw material purity or in the melting and forming appears first in the finished product. The demand for adherence to specifications reflects this fact. Faster melting rates in modern furnaces demand increased quality in raw materials. Subtle differences in composition can affect melting, viscosity, and the forming that takes place after melting is complete. Impurities can also diminish the properties of the finished product (index of refraction, tensile strength, appearance, etc.).

Some glass making raw materials, like silica, are produced and consumed within a limited geographic area. Therefore, glass manufacturers have accepted regional differences in quality and price. Within the regional variations, certain minimum standards must be met with respect both to chemical and physical specifications. Most glass manufacturers recognize that raw material deposits have variations in chemistry from deposit to deposit. They often issue working specifications for each raw material location. These specifications give the tolerance limits for each raw material deposit.

The main applications of glass sand are in the manufacture of colourless glass containers, flint glass (float, sheet and rolled or patterned glass), and coloured (amber and green) glass containers. The silica content can vary depending on the particular application, but should generally exceed 98% minimum. The physical requirements of the various glass sands are similar, with a narrow grain-size distribution being required. The presence of oversize materials and fines can cause difficulties in the melting and refining process.

Mineral specifications
Silica sand is used in a wide range of applications, each requiring distinct mineral characteristics. Glass grade silica sand should possess a minimum silica content of 98.5–99% SiO_2, and 0.2–1.6% Al_2O_3, with constraints on alkalis, colorants (Ni, Cu, Co) and refractory minerals. Fe_2O_3 content varies according to the type of glass being manufactured: <0.04% for flat glass, 0.03% for flint container, 0.18% for amber containers, and 0.3% for fibreglass.

Silica sand production, by country
Around 55.3 million tonnes of silica sand is transported between various countries worldwide with a value of US$ 664 million. Much of this is silica for glass-making but foundry sand, filter

sand and of course construction sand such as Indonesia supplying much of Singapore's concrete-making sand is an example of large tonnes at relatively low price.
Australia accounted for 3.3 million tonnes of this with a value of US$42.2 million, making the average Free on Board (FOB) price around US $13-14 per tonne. Silica for glassmaking usually sells at a slight premium over that used for foundry applications. An exception is the high alumina sand from Western Australia, which commands a slight premium in Japan as it does not need additional alumina added, which saves batch costs.

Table 3. Exports of Silica Sand from Australia

Year	Tonnes millions t	Value $US millions	Value /T FOB
1996	3.2	44.7	13.91
1997	3.2	46.6	14.19
1998	2.9	38.3	12.81
1999	2.9	38.7	13.18
2000	3.3	42.2	12.53
2001	3.1	42.0	13.32
2002 (e)	3.1	42.0	13.30
2003 (e)	3.1	42.0	13.30
2004 (e)	3.0* *Includes 1.3 mt to Japan	42.0	13.30

Table 4. Import Statistics for Silica Sand into Japan 2004

Country	2004			Expected end uses
	Qty (tonnes)	Value $US	Value $US /t	
Korea	20	69,391	3,469	Specialty for electronics
China	595,047	11,777,001	19.80	Glass & foundry
Taiwan	18,320	3,096,867	169	Specialty for electronics
Vietnam	156,200	2,674,998	17	Foundry, glass & sodium silicate
Malaysia	57,971	1,304,621	22.50	Glassmaking
Indonesia	9,001	33,335	3.70	Construction sand
Norway	1,038	1,052,667	1,014	Specialty quartz for induction furnaces
Sweden	114	22,784	200	Quartz for induction furnaces
Belgium	8,674	1,357,697	157	Likely Cristobalite (calcined silica)
Germany	175	137,130	784	Specialty for electronics
USA	5,580	6,265,938	1,123	Specialty for electronics
Australia	1,301,039	50,459,773	38.80	Mainly for glass, foundry. Some for motherglass (from Tasmania)
Total	2,153,346	78,283,376	36.35	Main uses are Glass, foundry & sodium silicate. Smaller volumes for special sectors

Source: Trade Stats

Japan imports close to 45% of its silica sand from Australia being around 1.3 million tonnes from Australia (2004) valued at US$39 million dollars giving a Cost insurance and freight (CIF) price of between $26-27 per tonne, thus the freight is around half of the delivered cost to the customers. The costs of road transport, local storage etc would add to this amount by an estimated US$10-15 per tonne.

Glass-grade Silica Sand for Export by Source Country

1. Australia

Australia has been a major exporter to Japan, Korea, Taiwan and Philippines for many years.
Main exporters of glass grade sand include Cape Flattery, in Northern Queensland. This huge resource is famous for good quality and large tonnages to Japan, Korea, and Taiwan. Recent shipping rates have had an impact but this will be a major supplier for many decades to come. This is really the benchmark by which all other deposits are measured. Operating since 1967, the Cape Flattery Mine Site covers a lease of around 6500 hectares and has an estimated resource of over 500 Million tonnes of silica sand.

Table 5 Cape Flattery Silica Sand

	Specifications	**Normal**
Fe2O3	130ppm Absolute Max 150ppm	110ppm
GFN	62 ± 3	60
> 800 micron or 20 mesh	0%	0%
> 600 micron or 28 mesh	0.5%	0.5%
> 300 micron or 48 mesh	20%	15%
< 100 micron or 150 mesh	2%	2%

Source: Company data.

North Stradbroke Island, also in Queensland, is virtually an island of sand and is a source since 1971 of low iron silica sand. It is pure enough to use for making solar panels, likely to become a major source of power in the future. This mining operation is owned by Unimin Australia, part of the Sibelco Group of Belgium and the largest silica sand supplier worldwide. Typical specification is SiO_2 >99.65%, Fe_2O_3 0.01%,Al_2O_3 0.03,TiO_2 0.035%,CaO 0.013%,MgO 0.013,Na_2O 0.013,K_2O 0.013

Mourilyan Silica Sand A new glass sand project is being developed again in Queensland. This Project, owned 100% by Calcifer Industrial Minerals Ltd, is located 100 km south-southeast of Cairns in North Queensland. The Mourilyan silica sand deposit contains in excess of 10 million tonnes of high grade silica sand. The Mourilyan Silica Sand Project is capable of producing and exporting at least 200,000 tpa of high grade silica sand, with a mine life in excess of 30 years. The Project would aim to export shipments of 30,000 tonnes size through the Port of Mourilyan Harbour each year. The Project requires minimal infrastructure. It is able to access existing roads, store bulk sand products inside a large covered Mourilyan Bulk Sugar Terminal storage shed (owned by Queensland Sugar Limited) and load bulk cargo ships through fully automated, computer controlled weighbridge, conveyor handling and C6 ship loading facilities at Mourilyan Harbour (owned by the Ports Corporation of Queensland). The Mourilyan silica sand deposit contains large resources of undeveloped high-quality silica sand, situated near well-developed transport infrastructure. It is one of the few remaining silica sand deposits capable of being brought into production in Queensland or Australia. Partners are being sought.
Western Australia has three large silica sand producers exporting to glass producers in NE Asia.
Approximate composition of the sand from selected producers is shown below.
Bunbury Silica Sand SiO_2 99.9%, Fe_2O_3 0.01%, Al_2O_3 0.017%,TiO_2 0.05% Mainly for glass. Rocla Quarries. SiO_2 99.88% Fe_2O_3 0.008% Al_2O_3 0.017% TiO_2 0.001% Foundry, sodium silicate and glass. TT Sand Pty Ltd SiO_2 99.9%, Fe_2O_3 0.01%, Al_2O_3 0.017%, TiO_2 0.05% Mainly for glass.

2. Malaysia.

Recent Government initiatives are in place now to reduce export of silica sand as a raw material and instead produce glass, ceramics and other value-added products to maximise returns to this country. This is a wise decision as it reduces early depletion of a finite resource. Bintulu in Sarawak province in East Malaysia (near Brunei) has some of the best glass sand reserves. Glassmakers in Peninsula Malaysia use both local silica from Jahore state and some imported sand for specialty glass such as CRT.

3. Indonesia.

Belitung and Bangka Islands are both well endowed with mineral resources including silica sand, often a by product of tin and kaolin mining. This silica is widely used in Indonesian glass and ceramics as well as providing excellent construction sand at relatively low prices.

4. Taiwan

Taiwan, as we know, lacks many mineral resources, but this has not stopped it becoming a leader in quality glass production among many technical fields of endeavour. There has been a migration of production of glass products (along with ceramic tiles and sanitaryware) to China mainland, often in Fujian province. This has helped both China and Taiwan immensely. The trend to keep the cutting edge industries including thin panels etc in Taiwan allows use of its immense talent-base in various Science parks throughout Taiwan, many with USA experience in Silicon Valley and elsewhere.

5. South Korea

Korean Imports of Silica Sand used primarily for glass, sodium silicate manufacture and foundry applications. Korea imported 1.537 million tonnes of silica sand in 2004 at an average value per tonne of US $27 per tonne CIF. The three main source countries were Australia 30.7%, Vietnam 23.7% and China with 21% with the balance of less than 20,000 tonnes from other countries. Korea has very modern cutting edge glass technology and along with Japan and Taiwan are a leader in flat panel design and manufacture. Like Japan and Taiwan the CRT glass industry has all but moved to China but the advanced design in companies such as Samsung are world leaders. Much of Korea's silica sand has come from Australia in the past decades, but Vietnam and China are both increasing market share, mainly due to freight differentials. Korea's drive into nanotechnologies including glass panels etc is keeping them at the forefront of technology in the region.

6. Japan

Japan lacks its own good silica reserves by the nature of its geology, primarily volcanic arc mountains. Large volumes of silica are produced from granite and aplite crushing and beneficiation but with high costs very much evident, Japan relies heavily on imported silica for glass making. Most is sourced from Mitsubishi's Cape Flattery silica sand operation in North Queensland, and alumina-rich silica sands in Western Australia. Vietnam and China are both chasing market share, primarily through better logistics, which impacts on the delivered price. China however, with internal demand rising virtually each quarter, is coming to realise it might be preferable, indeed astute, to keep more of its resources at home or risk running low in the years ahead. It has been stated if each home in China is to have a television set by the time the Olympics are held, then raw materials such as glass-grade silica and other key materials should be conserved rather than exported. This is already having an effect on some of Japan's imports. Most of the big silica sand suppliers have direct links and sometimes financial partnerships with the major glassworks here.

7. Vietnam

Vietnam due to geology and geography is well endowed with good silica sand deposits. Various Vietnam Localities, mainly on the coastal strip around Da Nang, are known to contain considerable quantities of silica sand. In recent years some of these deposits have been opened up to compete in export markets, primarily to Japan, Korea, Taiwan and the Philippines. There are some mainjor deposits in provinces, namely: Quang Ninh, Da Nang, Quang Nam, Khanh Hoa**.** The deposit in the Khanh Hoa province is said to be the most viable long term resource, is located at Thuy Trieu, 18km south of Nha Trang and 19 km north of Cam Ranh harbour. The Truy Trieu silica sand deposit, commonly called the Cam Ranh deposit, is owned by the Khanh Hoa Mineral Exploiting-Processing and Export Co (Minexco) and has proven reserves around 36 million tonnes. Production is around 200,000 tonnes per year of silica sand and is exported around the region for use in glass, ceramics and fillers. The Van Hai deposit, 110 km from Haiphong port in Quang Ninh province has more than 10 million tonnes in proven reserves of silica sand of which half is 98.1-98.5% SiO2 and only 0.09-0.2 % Fe2O3. At the moment, the sand from Van Hai deposit is mainly supplied to local glass producers. The Nam O deposit is located in Danang City and this deposit has more than 6 million tonnes of silica with a grade or 98.06% SiO2 and 0.08% Fe2O3. However, because of rapidly developping of urban and industrial zones in this area, the available reserves are only about 2 million tonnes. In Quang Nam province, there are 2 big deposits: Thang Binh (10,5 million tonnes) is being developed by Quang Nam Mineral Industry Corporation (Minco) and Nui Thanh (13 million tonnes). A new processing plant is being developed at Nui Thanh, called Chu Lai Silica Co.(CSC) This facility, to be managed by Vitis Co Ltd, will produce around 250,000 tonnes per year and begin operating around mid 2006. It has modern facilities and will produce a range of quality sands including glass grade. Capacity is likely to rise in the first few years of production, following marketing.

8. Philippines

The Philippines has some excellent glass grade sand on Palawan Island SW of Luzon. Some years ago this was mined for the local glass manufacturing industry, but a decision was made to preserve the sand for tourism value, probably a good idea in such a beautiful part of the world. As a consequence, now most glass sand is imported from Australia and Vietnam.

Conclusions

The vast Asia Pacific region has plenty of glass grade sand, but as is often the way, it is not where it is needed. Consequently the huge economies of Japan, Korea and Taiwan will need to continue importing high purity, correctly sized sand from countries such as Australia and Vietnam both richly endowed due to the geology of their environment and proximity to export ports.

Figure 3. Map of Asia Pacific Region showing some of the Suppliers of Glass Grade Sand

Courtesy: Vitis Company Ltd, Vietnam