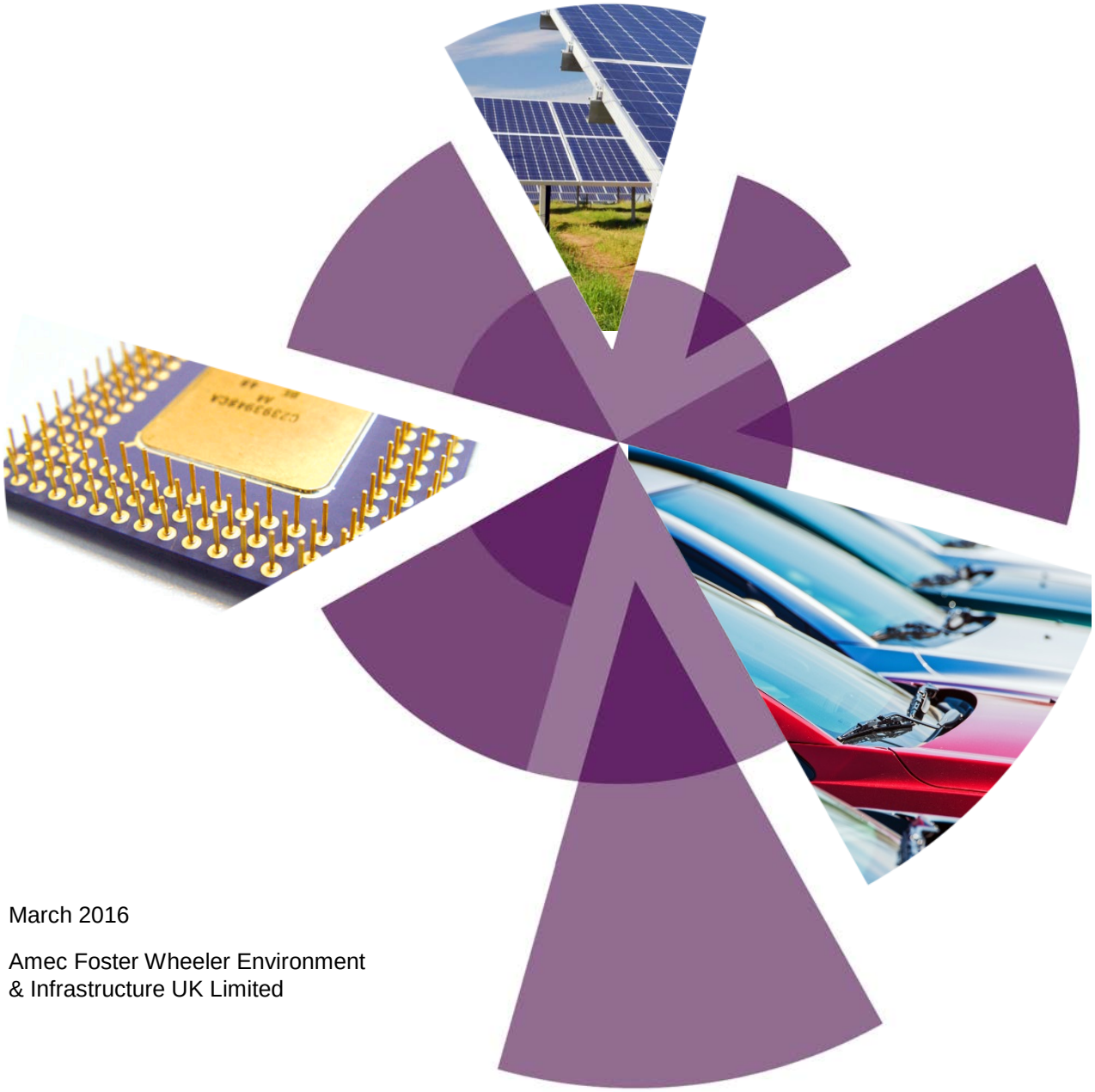
Global Silicones Council

Socio-economic evaluation of the global silicones industry

Regional Summary – Asia



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Amec Foster Wheeler Environment
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Report for

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Document revisions

No.	Details	Date
1	Draft report	01/10/2015
2	Revised final draft report	18/12/2015
3	Final report with further revisions	03/03/2016

Key Messages - Asia

Purpose of the report

This summary provides key information to stakeholders on the important contributions that silicones and the related materials, silanes and siloxanes, make to **Asian society** (Australia, China, India, Indonesia, Japan, South Korea and Taiwan). Further summary reports are available for the Americas and Europe, alongside a more detailed global report.

Silicones

Silicones in the context of this study are a group of high performance materials that include ***silicone polymers***, ***silanes*** and ***siloxanes*** and from which ***silicone products*** derive. These substances/ formulations are used in millions of products that we come into contact with every day. While the content of silicone is often small by the time consumers interact with them, the benefits that they offer are often significant. Their properties deliver performance characteristics on which the technical viability and economic efficiency of many products and processes depend. The use of silicones is so extensive that this report has focused on eight "key markets", discussed further below.

The silicones industry

Based on 2013 turnover of the contributing silicone industry member companies, silicones manufacturing is a ¥1,320 billion global industry, with 2,122,000 metric tons of formulated silicone products sold. Sizable manufacturing operations are located in Asia. Total sales of silicones products to Asia account for ¥540 billion and around 850,000 metric tons. These sales created a further ¥1,500 billion in added value from the sales of 'final' silicone products across Asia (around $12.7 billion). The majority, over ¥537 billion was created via sales to Japan, with similar amounts via sales to China ¥515 billion. Substantial values were created in South Korea (some ¥189 billion), Taiwan (¥75 billion) and India (¥57 billion).

Revenues generated by silicone sales comprise significant proportions of total company revenue accounting for 28% on average, which indicates the importance of these product lines to several major companies. The silicone industry is a highly innovative sector continually investing in novel products and technologies. Global research and development (R&D) related to silicone product lines amounted to ¥56 billion, around 4% of turnover; almost double the average R&D investment as a proportion of GDP amongst OECD countries.

Silicone manufacturing alone directly employs just under 30,000 people across the globe, almost 10,000 are directly employed in Asia. Collectively it is estimated that these employees earn ¥48 billion in gross salaries which supports taxation revenues alongside indirect economic activity through consumer spending in the various countries in which they are based. Significantly greater employment numbers are indirectly related to silicone products along supply chains. It is estimated that up to 10 million people may be employed in economic activities that in some way relate to silicone products, whether formulating, distributing, integrating silicones products into larger components, or selling products that contain silicones across Asia.

The silicones supply chain and 'enabling characteristics'

Almost 850,000 metric tons of silicone containing products were sold to eight "key markets" in Asia. These markets are summarized below, alongside infographics summarizing the wider benefits that silicones help deliver in these products.

- **Transportation:** Silicones are used extensively in automotive and aviation components as well as in boat building to avoid fouling on boat hulls. They are also used as coatings for air bags, which save thousands of lives every year. They contribute to increased durability and reliability, reducing maintenance costs. They help reduce weight/ friction alongside performance characteristics (e.g. heat resistance) that have enabled new component design, reducing fuel use as well as associated emissions. Fuel efficiencies gained through weight reduction are significant, saving around $125 per car every year. In 2013, around 41,000 metric tons of products were sold in Asia, with a direct sales value of ¥49.5 billion.

- **Construction materials:** A total of 173,000 metric tons of silicone product was sold to the sector in Asia, with sales of ¥72.5 billion. Products comprised a wide range of sealants, adhesives and protective coatings often developed with specific characteristics. As they provide a strong, durable, weather and UV resistant seal, with excellent adhesion to a range of materials, silicone sealants are used extensively in building construction and maintenance, particularly high rise glass facades, where they enable design evolution. They are also used as a process additive in the manufacture of Polyurethane (PU) foam for building insulation, increasing building energy efficiency, whilst the hydrophobic properties of silicone coatings help to protect external walls from weather damage.

- **Electronics:** A total of 43,000 metric tons of product was sold to the electronics market, with sales of ¥72.5 billion; the highest value silicone product, on average, across all sectors. In this sector silanes are essential for the production of electronic grade silicone. Silicone sealants, silicone gels, adhesives, encapsulates and coatings protect electrical equipment as well as various components within electronic and Information and communications technology (ICT) equipment against heat, shock and contaminants. Silicones are used in semiconductors, printed circuit boards and electronic control units, LED devices and various equipment such as smartphones and laptops. Silicones are also used to insulate wiring as they provide excellent electrical insulation and durability. They contribute to improved thermal management and heat removal and have allowed the development of more powerful, smaller and lighter devices.

- **Energy:** A total of around 8,000 metric tons of product was sold to the energy market, with sales of ¥7 billion. Silicones are used in 90% of solar panels, where silicones aid durability and functionality, providing durable bonds and seals alongside electrical insulation. They are also used within metal-filled, silicone-based adhesives which provide a reliable interconnection of solar cells – supporting high electrical conductivity and flexibility while contributing to lower material costs. Silanes are also essential for the production of solar grade silicon which requires silicon of high purity. By providing stronger bonds their use helps improve the durability of wind turbine rotor blades. They provide efficient lubrication for internal rotating machinery alongside protective coating, encapsulation and bonding of internal components. They help maximise energy efficiency, increase operational lifetimes, decrease unit costs, accelerating wind energy deployment. In energy transmission and distribution, they increase durability and weather protection, decreasing the likelihood of part failure and electricity blackouts.

- **Healthcare:** A total of 4,000 metric tons of product was sold to the healthcare market generating sales of ¥5.3 billion; amongst the highest value silicone products. A combination of performance characteristics mean silicones are ideal for many medical applications. They are compatible with human and animal tissue and bodily fluids, are extremely soft and pliable and are tolerant of sterilization. Silicones are used in molds, tubing, dental care, prosthetics, respirators and intravenous drug and transfusion delivery systems, cooling caps for use after chemotherapy treatments, breathing tubes, hearing aids. They are also used in various medical adhesive applications, they are easy to remove without causing pain or damaging the skin.

- **Industrial Processes:** The largest single market accounting for over 355,000 metric tons of silicone products with a sales value of ¥155 billion. Silicones are used in a huge number of applications; including antifoaming agents in oil and gas and in pulp and paper manufacturing, plastics and coatings mold casting, hydraulic fluids, and additives for polymers. Silicone antifoams allow for higher extraction rates in the oil and gas industry. They help reduce water use alongside higher quality pulp and paper. Silicones provide higher durability and resistance in industrial coatings as well as improved performance of lubricants. Their resistance to high pressure, high temperature and chemical reactions is ideal for demanding industrial processes.

- **Personal care and consumer products**: A total of 128,000 metric tons of silicone products were sold into the sector, with sales of over ¥72.8 billion. Used in deodorants, hair, skin and sun care products, and make-up, silicones provide various characteristics in the final product including a glossy or smooth feel alongside processing benefits, allowing to keep costs low. In consumer products, silicones are used in household polishes and waxes, and in laundry detergents where their use helps to reduce energy consumption in washing machines.

- **'Special systems':** Around 97,000 metric tons of silicone products are used in various 'special systems', including: coatings for paper products; easy peel-off adhesive release in envelopes and packaging, hygiene applications, graphic arts, industrial use, and tapes; in pesticides and herbicides to increase

their efficiency for use in agriculture, aquaculture, forestry, and domestic purposes; in dry cleaning, enabling the cleaning agent to remove stains without water; in high speed printing techniques; and, needle lubrication and anti-foaming agents in the textile industry. In these applications silicones reduce cost and waste, keeping consumer prices low. Sales amounted to ¥62 billion.

1. Introduction

In November 2014, Amec Foster Wheeler was commissioned by the Global Silicones Council (GSC) to carry out an independent socio-economic evaluation (SEE) of the contribution made by the silicones industry to the global economy. The assessment focuses on the benefits of the industry itself, in terms of turnover and economic output, employment, contribution to international trade, economic competitiveness and innovation, but also explores the use and benefits of silicones in various products and processes. A global study has been prepared so as to ensure a consistent methodology and reflecting that many of the largest manufacturers sell silicones or silicone-based products across the globe. The study considers their use in a total of eight 'key markets'[1], and three 'global regions'; Europe, the 'Americas' and Asia[2] (see Figure 1).

This summary provides key information to stakeholders on the important contributions that silicones, and the related materials, silanes and siloxanes, make to **Asian society**. This is defined as Australia, China, India, Indonesia, Japan, South Korea and Taiwan. Further regional summary reports are available for Europe and the Americas alongside a more detailed global report.

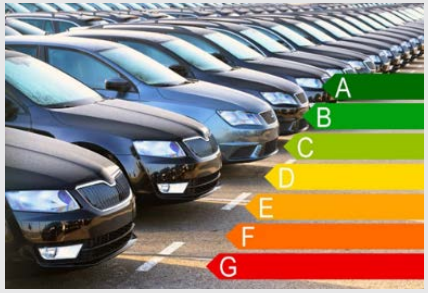
Silicones in the context of this study are a group of high performance materials that include ***silicone polymers***, ***silanes*** and ***siloxanes*** and from which ***silicone products*** derive. These substances/ formulations are used in millions of products that we come into contact with every day. While the content of silicone is often small by the time consumers interact with them, the benefits that they offer are often significant. Their properties deliver performance characteristics on which the technical viability and economic efficiency of many products and processes depend. The SEE draws on publicly available data, alongside a survey undertaken with members of the GSC carried out between February and May 2015[3].

Figure 1 Scope of the study (Countries and Markets)

[1] The key markets analysed are: transportation, construction, electronics, energy, healthcare, industrial processes, personal care, and "special systems".
[2] 'Europe' includes EU 28, Norway Switzerland and Turkey. 'Americas' includes Brazil, Canada, Mexico, and the United States (with additional analysis of a number of individual US States in the global report); 'Asia' includes Australia, China, India, Indonesia, Japan, South Korea and Taiwan.
[3] The Members who participated in the Study are: Bluestar Silicones, Dow Corning, Evonik Industries, Momentive Performance Materials, Shin-Etsu Silicones and WACKER CHEMIE AG.

2. Silicones – how and why they are used

Silicones are used to create parts, coatings and other important elements which are incorporated into thousands of articles and end products. Their presence is not always immediately obvious to the end user, consumer or to the relevant government authority. The use of silicones is so widespread that it is a challenge to identify and evaluate the full extent of their use and socio-economic effect. After consultation with members of the GSC, and a review of literature, a total of eight "key sectors" have been examined. These represent either the largest silicones markets (by sales or by volume) or where their role is considered to be particularly significant in terms of the performance characteristics of downstream products. The table below provides selected examples, for each key sector, illustrating important uses and benefits. Please note that additional technical detail is in the global report.

Market	Important uses	Key properties
Transportation 	• Silicones are used in various components within automobiles in the **car manufacturing** industry. The silicone products includes silicone rubber, resins, sealants, elastomers, lubricants, plastic additives and silicone coatings in air bags. • Silicones are also used extensively in the **marine vessels manufacturing**, for instance in coatings, to avoid fouling on immersed hulls, and in various internal and external components, including adhesives and sealants for various structural components. • Due to their unique properties, they are also used extensively and increasingly in **aviation** and avionics components.	• Overall silicones contribute to increased **durability**, **reliability** and **safety** and to reduced maintenance costs in the transport sector. • They help reduce weight and hence fuel use in end products, **improving the fuel efficiency** of cars, as shown in the picture on the left (which shows environmental efficiency ratings). Through their use in safety equipment, they contribute to reductions in road fatalities. • Their use increases processing speeds in manufacturing, thus driving down costs. Their performance characteristics and properties cannot be met by alternatives in the range of applications described earlier.
Construction materials 	• Silicones are used to seal joints and openings in various applications in **commercial construction**. • They are also extensively used in domestic **do-it-yourself (DIY)** applications, and in sealants for joints in paving, decks and concrete slabs. The level of silicone use in the sealant products is high and silicone forms an essential part of the formulation. • Silicone sealants are used in exterior applications for **weather-sealing of facades, structural glazing, perimeter sealing of windows and doors, expansion joints etc**. • They are also widely used in **interiors in floor joints, bathtubs, sinks, and showers to prevent water leakage and subsequent damage**. Silicones function as the base for water repellent paints, providing water repellence and surface breathability.	• Silicone sealants and adhesives bond with most materials. They are extremely durable and can resist rough weather conditions, moisture or sunlight. • They prevent humidity and hot or cold air from coming through joints and cracks, leading to significantly higher energy efficiency. The advantages of silicone adhesives and sealants include: **flexibility; superior resistance; and compatibility with a variety of different substrates.** • Thanks to their properties, silicone sealants and adhesives enable the technical feasibility of certain architectural designs, especially 'high rise' and glass facade buildings. They **reduce maintenance costs** as well as the safety risks posed by high rise repair or inspection.

Market	Important uses	Key properties
Electronics	• Silanes, the starting material in the production of silicones, can be functionalized and are used for a wide variety of other applications. Silanes are indispensable for production of electronic grade silicon, which requires silicon purity of up to 99.9999999% (9N), and they are a key component in the production of **semiconductors**. • In electronics, silicones are used across a huge number of specific products used across various sectors, such as **electronic chips**, semi-conductors, printed circuit boards (PCBs) and electronic control units (ECUs), **LED devices**, and various ICT equipment. • Silicone sealants, adhesives and coatings are used, among other things, to produce circuits, connectors, capacitors, coils, transistors and tubes in electronic devices for most consumer and business applications.	• Silicones are stable over a wide temperature range from -40C to +180C. They have important properties in terms of volume **resistance**, **insulation,** ability to withstand high voltage, high adhesion, photo thermal stability and **durability**. • Their use contributes to increased functionality and performance at the same time, as well as to lower weight and cost. • Silicones also aid production efficiency by simplifying manufacture and assembly. • Their use helps protect electrical equipment against heat, shock and moisture, ensuring the durability of devices. This is critical to ensure long-term stability and performance in a large numbers of electrical products.
Energy	• Silicones are used in a variety of application in the energy sector, some of which are as illustrated below. • As in the electronics sector, silanes are essential for the production of solar grade silicon which requires silicon of high purity. Around 90% of solar (photovoltaic) cells are based on silicon. Silicones provide good electrical insulation and serve as a stable base for conductive adhesives that are used in **solar panels**. • They are used as sealants and adhesives for bonding in conventional solar panels, and they are also used as part of thin semiconductors for the 'new generation' of solar panels. • Silicones are used as adhesives to bond the rotor blades in **wind turbines**, as coating for glass fibre blades and as lubricants of rotating machinery. • Silicones are also an important insulating component in energy **transmission** and **distribution**.	• The **temperature resistance** of silicones ranges from -60ºC to 180ºC, while their low reactivity towards polluted air and water enable their resistance to weathering. • They have high resistance to ozone and UV radiation and to degradation arising from electrical currents. They also have good mechanical properties (**flexibility**) and they are flame-retardant. • Overall, silicones' properties enable more reliable, durable and efficient solar panels and for more **efficient** wind turbines. • They protect underground/ undersea cables making them more **reliable and longer lasting without replacement or failure**. • Their use in **energy transmission and distribution increases durability and weather protection, decreasing the likelihood of part failure and hence ensuring the continuity of electricity supply**.

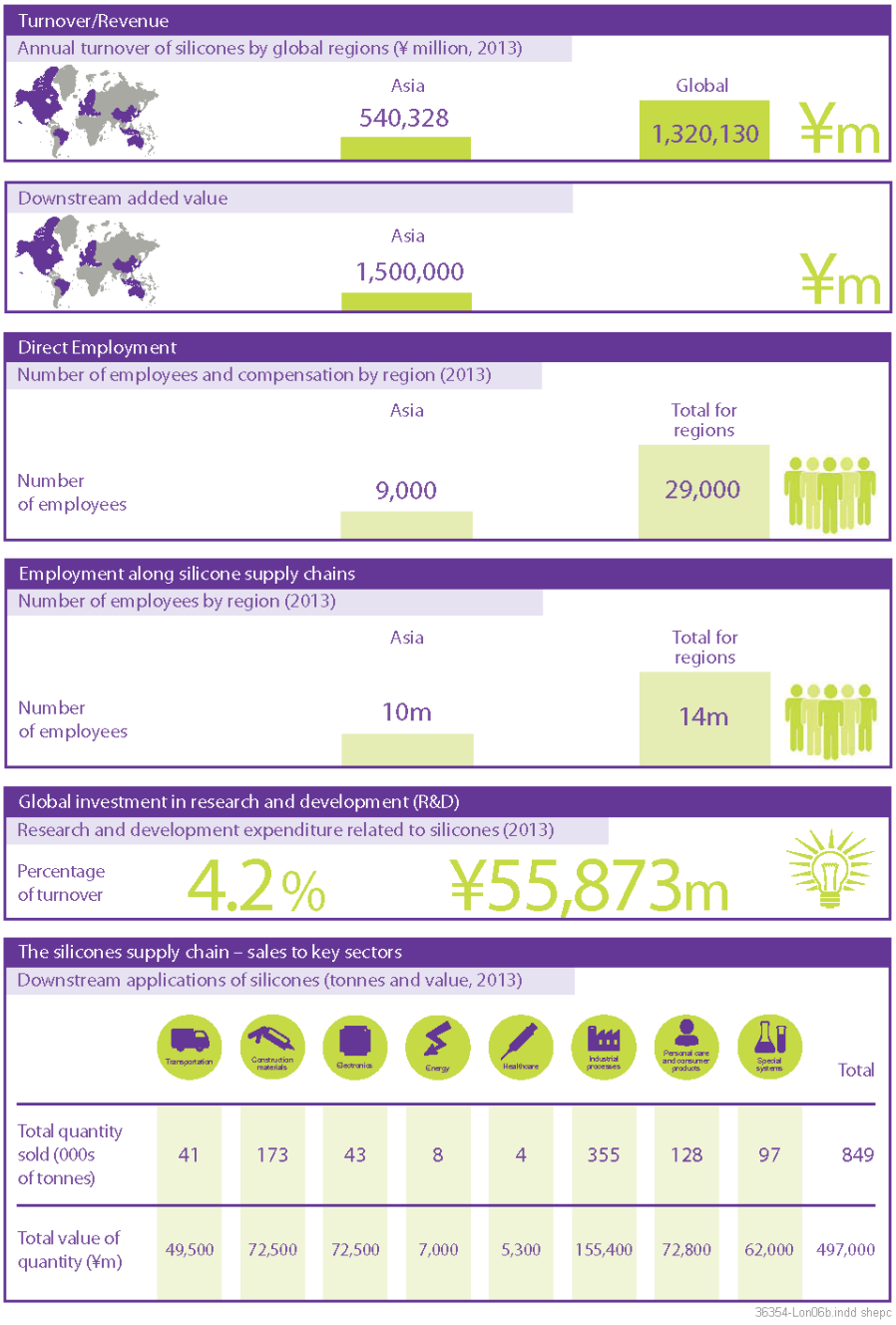
Market	Important uses	Key properties
Health care	• Silicones are one of the most widely applied biomaterials, and they have been used in a wide range of health care applications, including **orthopaedics, catheters, drains and shunts, components in kidney dialysis, blood-oxygenator, heart-bypass machines, heart valves and aesthetic implants amongst others. Some of the main applications include: molds, tubing and various 'enabling components'; adhesives and coatings; antifoams; control release devices; lubrication; and, topical medication**. • Silicones have also a wide range of applications in the **pharmaceutical sector, where they are used in many registered pharmaceutical products both as actives and as excipients**. They have been found in the formulations of more than 350 registered drug products as actives or excipients	• Silicones are **biologically inert** (i.e. do not promote bacterial growth or irritate tissues), conform to different cavity shapes (e.g. they can be extremely soft and pliable) and are tolerant of sterilization methods. • They are known for biocompatibility and biodurability due to their inherent chemical and thermal stability, low surface tension, hydrophobicity, and resistance to sterilization methods. • Silicones are hydrophobic, hypoallergenic, and non-reactive with most chemicals. Their **chemical stability**, durability and elastic nature makes silicones suitable in applications involving long-term implantation in the human body. • Silicone **antifoam properties** makes them ideal for use in pharmaceutical formulations. • Overall, silicones have played a very important role in health care, enabling the development of advanced technologies.
Industrial processes	• Silicones are extensively used within various industrial processes. Examples of the wide variety of uses include: **lubricants, anti-foaming agents in offshore drilling and paper production, industrial coatings, and paint additives**. • Silicon-based sealants are used in demanding industrial processes requiring **resistance to high pressure, temperature and corrosion, and adaptation to all types of surfaces**. • Silicones are used to enhance coatings, providing various components with increased durability and resistance to chemicals, corrosion and high temperatures, reducing maintenance costs or unplanned maintenance for industrial infrastructure and machinery. Silicones' properties enable them to be used as hydraulic fluids and additives for polymers for a variety of applications.	• Silicones provide higher durability and resistance in industrial coatings as well as improved performance of lubricants. • Their **resistance to high pressure, high temperature and chemical reactions is ideal for demanding industrial processes.** Not only are they used as polymers, they can also be added to polymers from other materials to improve their performance. • The characteristics that facilitate their use in the sector are, among others: temperature and ozone/ UV resistance, flexibility and other good mechanical properties, **low shrinkage, deformability and viscosity.** • Overall, silicones increase production efficiency and lower costs. They provide durability and reliability of equipment, decreasing the risk of downtime and reducing maintenance costs.
Personal care and consumer products	• Silicone polymers and cyclic siloxanes, (referred to here under the generic term 'silicones') are used in the personal care sector as a solvent and carrier for a number of personal care products, including **deodorants, haircare products, sun-care products, skin-care products and make-up products**. • Silicones are also used as a solvent and carrier for a number of **households products, including polishes, waxes, and**	• The use of silicones in the personal care and consumer products sector is regarded as having several positive attributes for the environment and safety. • As a component of a consumer good, silicones have a long product life with good durability, and they are resistant to bacteria.

Market	Important uses	Key properties
	detergents. • Silicones are also used in various components within other **consumer products, including cooking utensils, sporting goods, baby and infant products, and furniture and bedding, among others.**	• As a solvent or carrier, **silicones reduce the quantity of personal care and household products consumed** (e.g. improved water resistance in sun-care products means fewer applications are needed, and silicones improve the effectiveness of washing detergents by reducing the quantities needed). • Silicones can **reduce energy consumption** through related processes, such as by reducing the length and temperature of a washing cycle, reducing both the need to iron and drying time.
Special systems	• Silicones are used as a solvent and carrier in a number of 'special system' processes, including **coatings (e.g. for textiles, leather, paper, packaging, labels, parachutes and air bags**). • The properties of silicones offer various advantages according to the purpose of the coating. In general, they are used to **improve durability, providing a lightweight option with capacity to withstand a wide range of temperatures**. • In addition, **silicones are used as a wetting agent for the application of pesticides and herbicides** (used for agriculture, aquaculture, forestry, and domestic purposes). The low surface tension of silicones allows the plants to absorb the pesticides/ herbicides without requiring irrigation or rainwater and meaning that fewer applications are often needed. • Silicones can be used to **facilitate production processes in several instances, for example for high speed printing techniques, where they reduce the process cost and waste**.	• Silicones provide stable performance such as **sealing properties, elasticity and constant chemical properties over wide temperature ranges**. • Silicone-derived products also display properties, such as: **low chemical reactivity; high gas permeability; adhesion on a large variety of substrates; elasticity; and, flame-retardancy**. • They also offer **processing advantages such as reduced energy and water consumption during manufacturing**. • Where used as solvents or carriers, silicones are useful for their **lack of colour, odour and taste, low surface tension, and low skin irritation. Their use can also improve the efficiency of active agents and improve product durability**. • Overall, **silicone-derived products are durable; they can withstand high and low temperatures (as well as offer protection from UV), resist water and moisture, and protect from chemicals, wear and tear, and bacteria.**

3. The Silicone Industry – Key Figures

This section summarizes the direct and indirect social and economic effects from the manufacture and sale of silicones in Asia. The data are presented graphically (Figure 2), with further commentary overleaf[4] [5].

Figure 2 Key figures on the Asian silicone industry



[4] All data in this section relates to 2013 unless otherwise stated. Data is expressed in Yuan, as well as in U.S. Dollars and Euro if relevant. Exchange rate: $1 = ¥119.56 (Source: http://www.x-rates.com/ (Average 2015 Jan - May)); Exchange rate: $1 = ¥119.56 (Source: http://www.x-rates.com/ (Average 2015 Jan – May)).

[5] To protect the commercially confidential information of individual companies, all data is aggregated and rounded. Where fewer than three survey responses have been received, data is either omitted or presented within a wider range. Confidentiality limits the level of detail possible in relation to uses within specific sectors/applications and countries.

Revenue

- Based on 2013 turnover of the contributing silicone industry member companies, the global silicones industry generates revenue/ turnover of around ¥1,320 billion. Asia generates revenue of ¥540 billion representing 41% of global turnover from silicones.
- Beyond silicones, GSC members manufacture several different product types, with global revenues from all products of about ¥4,700 billion. However, in Asia silicones comprise significant proportions of total company turnover: ¥540 billion of the total ¥900 billion revenue are silicone-related.

Direct Employment and earnings

- Silicone manufacturing and research and development is a major source of employment across the world. Globally, 86,000 people are employed by the companies taking part in the survey, of which 29,000 are directly related to silicones product lines.
- The companies located in Asia directly employ 11,000 people in total. Around 9,000 of these are directly related to silicone product lines which constitutes around 30% of total silicone related employment (note this excludes indirect employment along supply chains).
- In terms of gross salaries, employees related to silicone product lines earned a total of around ¥47 billion in Asia, which supports widespread indirect economic activity in the domestic economies from the expenditure of employees on housing, recreation, and goods and services[6].

Investment in research and development (R&D)

- The silicone industry is a highly innovative – and competitive – sector which continually invests in novel products. On average, 4.2% of the silicone-related turnover was invested in R&D activities. This amounts to an annual investment of ¥56 billion, which is almost two times greater than the estimated proportion of GDP spent on R&D in the OECD countries (an average of 2.3%).

The Silicones Supply Chain

Silicones are sold to a huge number of downstream sectors and used in millions of products across the globe. They may be used in multiple stages between manufacture and their ultimate use by the consumer - where typically they are found in fractional concentrations in the final product. This section briefly illustrates the silicones supply chain, providing key figures on silicone-based products for 2013[7] on each of the key sectors identified in section 2[8].

- **Transportation:** This includes car and automotive components manufacturers, aircraft and aviation components and manufacturers, military and ship builders. In Asia, around 41,000 metric tons were sold for a value of approximately ¥49.5 billion.
- **Construction:** This includes sealants and adhesive producers and distributors, DIY commercial suppliers, construction firms and contractors, PU and coating formulators. In Asia, around 173,000 metric tons were sold with a sales value of ¥ 72.5 billion.
- **Electronics**: This category covers a large range of applications, including semi-conductors, automobile electronics, computers, LEDs amongst others. It includes component

[6] These indirect effects are typically quantified using a combined or 'composite' economic multiplier. Multipliers quantify the further economic activity (jobs/expenditure or income) resulting from additional local income and supplier purchases. These are multiplied because of the knock-on effects of this type of expenditure.
[7] Note that there some minor inconsistencies are found between aggregated and regional data. These are because data from individual companies did not always fully match when split by region and when split by application. Furthermore, some data reported by companies were also approximations.

manufacturers, device designers and manufacturers. Some 43,000 metric tons were sold in Asia worth ¥72.5 billion.

- **Energy:** Applications in this category relate to solar power technologies and insulation. Among the components of the supply chain we find electrical equipment manufacturers, energy and utility firms, wind turbines manufacturers and transmission equipment suppliers. Around 8,000 metric tons of products were sold in Asia for a value of ¥7 billion.
- **Healthcare:** This category includes formulators and molders, device/ component manufacturers, public health care providers and pharmaceutical firms. Around 4,000 metric tons were sold in Asia with a value of ¥5.3 billion.
- **Industrial processes:** Among this category we find oil and gas refineries and plants, offshore rigs, energy companies, various industrial manufacturers. Sales in Asia amount to 355,000 metric tons worth ¥155 billion.
- **Personal Care & Consumer Products:** The sector includes, amongst others: formulators of deodorants, haircare, skin-care and make up; wholesalers and retailers of the above products; household detergent formulators and suppliers; and, manufacturers of sporting goods, cooking utensils and infant products. Asia accounts for some 128,000 of metric tons of products sold with a total value of ¥72.8 billion.
- "**Special systems":** This includes various applications in the textile industry, in adhesives and coatings, and agrochemicals. Around 97,000 metric tons were sold into Asia, for a sales value of around ¥62 billion.

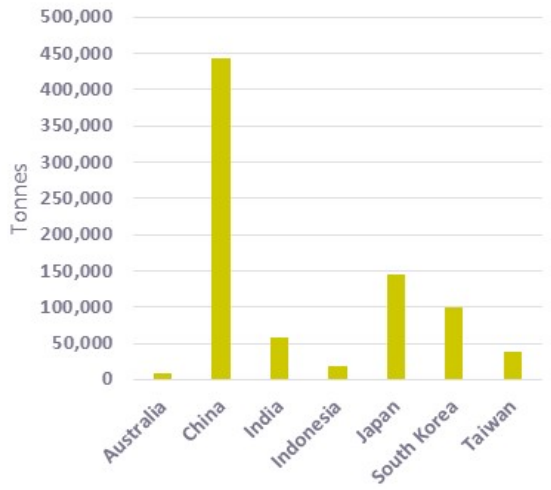
4. Sales of Silicones in Asia

This section provides further information on products containing silicones that were sold in Asia. The amount of detail that can be given is limited due to confidentiality, but the section illustrates the most important countries and sectors. It draws on data from the GSC members; further volumes may be manufactured by non GSC members in some regions. The data relate to products sold by the manufacturers. Note that at this stage, the products contain various additives in addition to silicones which differ depending on the product/ key market concerned.

As noted earlier, total global sales is more than 2 million metric tons, generating some ¥1.3 trillion revenue. Total sales in Asia are around 850,000 metric tons (roughly 40% of the global sales volume) generating a revenue of ¥540 billion.

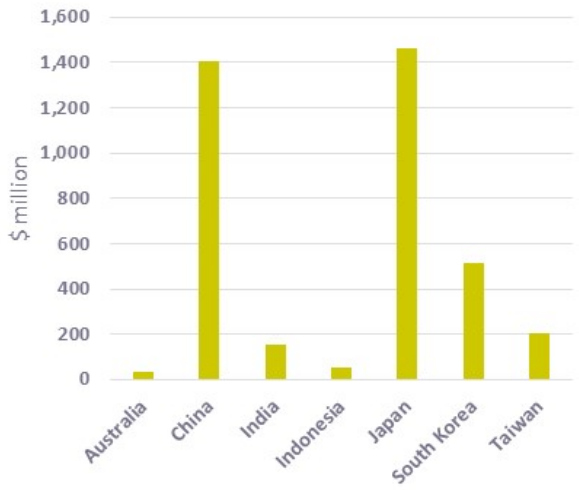
Figure 4.1 and Figure 4.2 provide data on the sales of silicones to various countries in Asia, in terms of sales volume and sales value. China is the largest purchaser of silicones in Asia; purchasing 442,000 metric tons in 2013, 54% of all the Asian sales. The market accounted for sales of almost $ 1.4 billion (¥167 billion). Japan accounts for the second largest volume, approximately 145,000 metric tons (18% of total Asian sales), but the largest market in terms of sales volume at just under $1.5 billion (¥180 billion). Other sizeable purchasers include South Korea (99,000 metric tons, 12% and $500 million, ¥ 60 billion), India (62,000 metric tons, 8% and just under $200 million, ¥24 billion) and Taiwan (39,000 metric tons, 5% $200 million, ¥ 24 billion).

Figure 4.1 Silicones sales volume: Asia (sales volume, metric tons, 2013)



Source: Amec Foster Wheeler GSC Survey, May 2015.

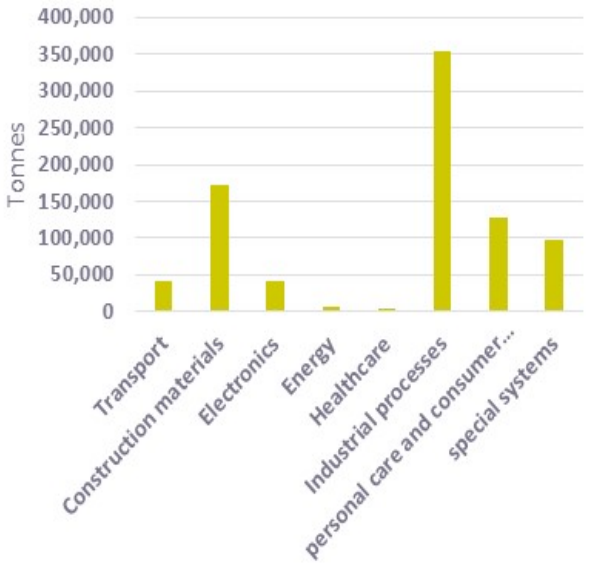
Figure 4.2 Silicones sales value: Asia (sales value, $ million, 2013)



Source: Amec Foster Wheeler GSC Survey, May 2015.

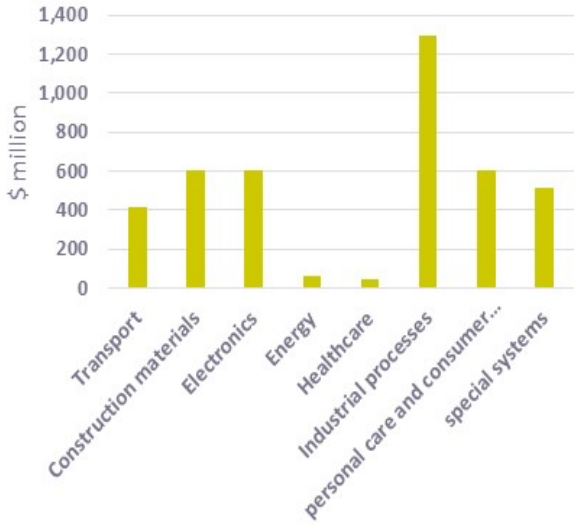
A summary of the volumes of silicones purchased in each sector within Asia is detailed in Figure 4.3below, with sales value in Figure 4.4. In line with silicone volumes sold globally, industrial processes is the dominant downstream user, accounting for approximately 350,000 metric tons purchased, or around 42% of all silicone products sold within Asia. Silicone products purchased within the construction sector account for 170,000 metric tons (20%) with a further 130,000 metric tons (15%) in personal care and consumer products and 100,000 metric tons in special systems. Transportation, electronics, energy and healthcare only contribute to small proportion (12%) of the silicone purchasers in Asia, similar to the findings at the global level.

Figure 4.3 Silicones sales in key sectors: Asia (metric tons, 2013)



Source: Amec Foster Wheeler GSC Survey, May 2015. Note the total volumes and values reported for sectors are greater than for the sum of the individual countries, reflecting small volumes of sales to other countries.

Figure 4.4 Silicones sales value: Asia (sales value, $ million, 2013)



Source: Amec Foster Wheeler GSC Survey, May 2015. Note the total volumes and values reported for sectors are greater than for the sum of the individual countries, reflecting small volumes of sales to other countries.

4.1 Asia Sector Analysis

The paragraphs below provide further details on sales by silicone manufacturers to downstream users, within 8 key sectors in Asia. Where there are less than three sets of data for any particular country, results have been removed for confidentiality reasons. The data below provides an indication of the relative demand/ extent of economic activity within each country, within the applications discussed.

Transportation

- As noted earlier, in the transportation sector in Asia a total of around 41,000 metric tons were sold in 2013, with a value of approximately ¥49.5 billion.
- Within this region the largest user of silicones products is Japan, with ¥33 billion (23,600 metric tons), 58%, of silicones purchased within the transport sector in Asia. This is likely to reflect its automobile sector.
- China was the next largest user accounting for ¥8 billion and 8,600 metric tons (21%) of silicones. India and South Korea were also significant purchasers, accounting for 2,800 and 4,700 metric tons respectively. Around 1,000 metric tons of silicone products with a value of ¥1.1 billion are sold to Taiwan.

Construction Materials

- In Asia, 173,100 metric tons of silicone-based construction materials were sold, with a value of ¥ 72.5 billion.
- In the construction sector the largest purchaser of silicone products was China accounting for 41% (67,600 metric tons) of the sales volume in this sector and region, and has a value of ¥ 18 billion, reflecting its fast growing economy.

- South Korea is the next largest purchaser of silicone products accounting for 38,700 metric tons (24%), a value of ¥ 10 billion.
- Although Japan is the third largest sector, accounting for 16% of the sales volumes, the total purchase value was slightly greater than China at ¥19 billion, which may reflect sales into different applications. Taiwan and India had sales of 11,400 and 9,400 metric tons respectively ¥ 4.6 and ¥ 4.7 billion sales respectively.

Electronics

- In Asia, around 43,000 metric tons of silicone-based products were sold in electronics with a value of ¥72.5 billion.
- There are two countries that dominate the demand market for silicone products in electronics: China and Japan. In 2013, 43% (18,400 metric tons) of the silicone products were purchased in China with a value of ¥20 billion. Japan, the next largest purchaser of silicones, purchased 39% (16,400 metric tons) of the silicone products. Despite the sales volume being lower than China, the actual value of silicone purchased in Japan was 55% greater.
- Other significant purchasers include South Korea (5,600 metric tons) and Taiwan (2,200 metric tons).

Energy

- Around 8,000 metric tons of silicone products were sold in Asia with a value of ¥7 billion in 2013.
- In this region, China is the largest purchaser of silicones in Energy, accounting for 48% (4,900 metric tons) of the sales volume with a value of ¥3 billion. Japan also accounted for sizeable volumes of silicones, purchasing 2,100 metric tons during the year. This is likely to reflect the strong solar photovoltaic manufacturing in both these countries.
- The other significant purchaser of silicones in this sector was South Korea, which is also known for its sizeable solar photovoltaic manufacturing sector[9] (500 metric tons; ¥0.6 billion).

Healthcare

- In the healthcare sector 4,000 metric tons were sold in Asia for ¥5.3 billion revenue.
- As with other key sectors, the two key countries in Asia for purchasing silicone products for use in healthcare are China (1,700 metric tons; ¥1.4 billion) and Japan (1,300 metric tons; ¥ 3.1 billion). The value of silicone tends to be greater in Japan (in this case double) compared to China. This is likely to reflect the mass export production of less specialist medical devices in China (e.g. tubes, medical plasters[10]) compared to more specialist applications in Japan (e.g. diagnostic imaging equipment; therapeutic and surgical equipment[11]).
- Silicones were also purchased by South Korea, Taiwan and Indonesia (200, 200 and 100 metric tons, respectively).

Industrial Processes

- Sales of silicone products in the Asian industrial processes sector amounted to 355,000 metric tons worth ¥155 billion.
- Unlike the previous sectors, significant volumes of silicones are purchased by a number of countries within the region in the industrial processes sector. China remains the most significant purchaser of silicones, accounting for 243,900 metric tons, approximately 70% of the

[9] http://www.enfsolar.com/directory/panel/Korea
[10] http://www.export.gov/China/doingbizinchina/industryinfo/healthcare/index.asp
[11] http://export.gov/industry/health/healthcareresourceguide/japan084194.asp

sales volume in Asia. This is likely to be driven by many industrial process industries but particularly oil and gas, where China is one of the largest oil and gas producing countries in the world, producing more than 4 million barrels per day in 2010[12].

- Other significant purchasers include Japan (44,500 metric tons) and South Korea (27,500 metric tons).

Personal Care and Consumer Products

- Asia accounts for some 128,000 of metric tons sold in this sector, with a total value of ¥72.8 billion.
- Similar to the industrial processes sector, a number of countries in the region tend to be purchasers of silicone products. China is the largest purchaser in the Personal care and consumer products sector, accounting for 42% (49,900 metric tons) of sales volume, a value of ¥26 billion.
- India is a significant purchaser of silicones in this sector, accounting for 16% (19,700 metric tons) of sales volume, a similar level to Japan (19,000 metric tons). Although India and Japan purchased similar volumes, the value of the goods in Japan is over four times greater (above ¥ 20 billion), reflecting their use in higher value applications.
- Other major purchasing countries include Indonesia (8,800 metric tons), South Korea (12,600 metric tons) and Taiwan (7,100 metric tons).

Special systems

- Around 97,000 metric tons were sold into Asia, for a sales value of around ¥62 billion.
- China accounts for the largest proportion (55%, 47,400 metric tons, ¥21 billion) of silicones purchased within the region and is likely to represent its extensive textiles manufacturing industry.
- Other major purchasers include India (14%, 11,900 metric tons), Japan (13%, 10,900 metric tons) and South Korea (11%, 9,600).

Employment along the silicones supply chain

The silicone products manufactured by the employees above are sold to thousands of different companies across the globe who carry out further processing, formulation or integration of silicone components into final products. Therefore the sales of silicone products indirectly support a much larger number of employees in various downstream sectors. The extent of this downstream employment was not possible to identify through the GSC survey, so data collected in a previous study “a Socio-Economic Study of Silicones in Europe, published by the European Silicones Centre (CES)[13] has been adjusted to provide a regional and global estimate.

The CES study estimated downstream employment in Europe, which drew on empirical data on the size of downstream supply chains developed in consultation with the manufacturers. It shows the numbers employed in silicone manufacturers, formulators and distributors, end user sales companies and ‘indirect companies’. The CES analysis shows that the number of employees in the total downstream supply chain are some 178 times the original number employed by the manufacturer of silicone products. This data has been adjusted to provide a consistent approach to estimating employment along supply chains, as follows:

- The data in the CES estimate of downstream employment was converted into a scaling factor, showing how the numbers of employees increases at each stage of the supply chain. For instance the CES study showed that in all sectors there were some 18.5 times the number of

[12] https://www.iea.org/publications/freepublications/publication/China_2012.pdf
[13] http://www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study_brochure_v45.pdf

employees in formulators and distributors than the number employed by silicones manufacturing, and so on (see the table below).

- This scaling factor was applied to the data from the GSC survey on the total number of employees in silicones manufacturers in Asia. The number of people employed in Asia is much greater than across Europe, so a further scaling factor was applied to reflect the size of the labour market in Asia compared to that in Europe. Cleary this is a high level estimate, but it serves to show the approximate scale of employment along the various supply chains.
- This estimate suggests that up to 10 million people may be employed in economic activities that in some way relate to silicone products, whether formulating, distributing, integrating silicones products into larger components, or selling products that contain silicones across Asia.

Table 3.1 Indirect employment along silicone supply chains – Asia (based on adjusted European data) (2013)

	Silicone manufacturers	Formulators and Distributers	End use sales companies	Indirect companies	Total
Scaling factor (taken from CES study)	~	18.5	45.6	105.5	170.6
Scaling factor Total Asian employment compared to total European employment					6.5
Total Asia	9,000	1.1 million	2.7 million	6.2 million	10 million

Source: Amec Foster Wheeler based on data from the GSC survey on direct employment. Data from a Socio-Economic Study of Silicones in Europe, published by the European Silicones Centre (CES) http://www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study_brochure_v45.pdf on employment scaling factors. And data on total employment in the European, Americas and Asian countries within the scope of the study was taken from the International Labour organisation (ILO) https://www.ilo.org/ilostat/faces/help_home/data_by_subject?_afrLoop=2138106775318101#%40%3F_afrLoop%3D2138106775318101%26_adf.ctrl-state%3Di432g0u8l_400. Note data from India was not available from the ILO hence data from the World Bank was used. http://data.worldbank.org/indicator Note that the estimates are approximate and aim to demonstrate orders of magnitude rather than precise values. Note that numbers have been rounded.

Downstream added value

As with employment, further economic activity takes place at various subsequent stages as the formulated silicone products are integrated into various further products. A high level estimate of the added value along various supply chains is below, this captures the difference between the value of the inputs and of the outputs. This highlights the scale of overall economic added value related to the sale of silicones. As above, the approach draws the CES study because the data used in that study was developed with many of the same companies who participated in this survey.

Full details of the approach is explained in the global report, but the estimate uses a scaling factor which represents the difference between the added value of the final products and the formulated products. This was applied to the sales value of formulated silicones in each country. The values are also adjusted to reflect the structural economic differences between the European economy and the others considered in the study. The adjustment is based on relative economic value added per employee in relevant sectors in different global regions. The results provide an approximate high-level estimate of downstream added value.

- A total of ¥1.5 trillion added value was created from the sales of 'final' silicone products across Asia (around $12.7 billion). The majority, over ¥537 billion was created via sales to Japan, with similar amounts via sales to China ¥515 billion. Substantial values are created via sales to South Korea (some ¥189 billion), Taiwan (¥75 billion) and India (¥56 billion).

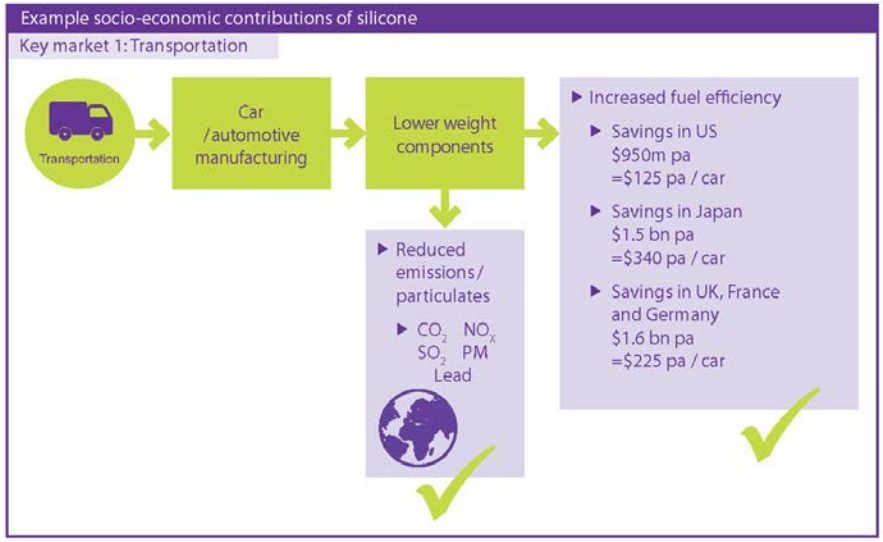
5. The Socio-Economic Value of Silicones

This section summarizes the wider socio-economic benefits arising from the downstream use of silicones and of products that contain silicones. This is done by evaluating two things. First, the socio-economic importance of the sectors where silicones are extensively used. Second, by summarizing what silicones actually do that is useful for industry and consumers – this is termed their 'enabling characteristics'. Greater technical detail is in the global report, this section summarizes only the key messages.

Transportation

The car manufacturing industry generated ¥83,000 billion in revenue across Asia in 2005, and directly employed 2.6 million people with 1.6 million in China alone.

- Their use prolongs the useful life of various performance and safety critical components by providing **durable and effective protection against moisture, dirt and shock.** Silicones are also used as coatings in air bags providing **airtight seals**, and fabric **strength and durability.** They contribute to **increased safety and reductions in road fatalities**.
- **Silicone components contribute to weight reductions of vehicles,** which results in **increased fuel efficiency** and **lower emissions** of various pollutants, mainly CO_2 but also volatile organic compounds, NO_X, SO_2, Particulate Matter and Lead[14] which are all known to cause adverse effects to human health and the environment. A 2012 study concluded that the **fuel saving** attributed to weight reduction enabled by the use of silicones was as much as 20%[15].
- Estimates based on the number of vehicle miles driven and cost of fuel per gallon suggest that, as a result of the above fuel savings, a total of $1.5 billion (¥180 billion) is saved in Japan per year; around $340 (¥40,000) per car.

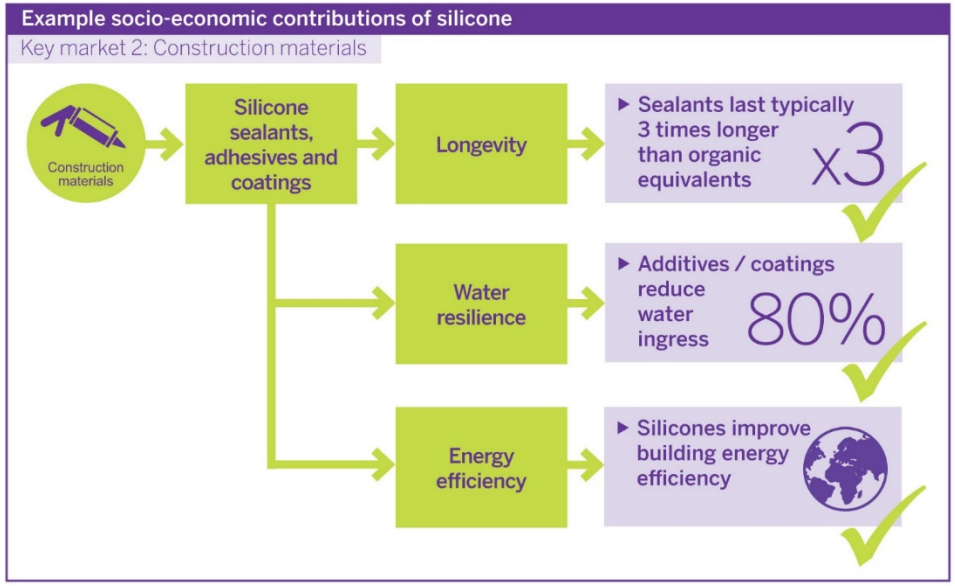


[14] https://fortress.wa.gov/ecy/publications/publications/0002008.pdf
[15] Source: Si Chemistry Carbon Balance, Denkstatt (2012), this figure was derived via industry consultation. Page 125 Case Study: Silicone Rubber in Motor Construction. Note that the basis of this fuel saving is the weight saving that has been enabled by the use of silicones.

Construction materials

The global construction sector had a market value of ¥1,040 trillion in 2012 (forecast to reach ¥1,793 trillion by 2025). The sector accounts for ~10% of employed persons in in Japan, and ~9% in China. Employment growth in the sector has been particularly evident in India where 41% of the jobs created between 2000 and 2010 were in construction.

- Silicone-based products are often twice, or more, durable than the alternative: **by providing additional longevity, silicones reduce lifecycle costs,** offering substantial savings. An example published by Dow Corning evaluates the potential cumulative savings using a silicone sealant to recaulk an 8-storey building, suggesting savings in this instance of ¥15 million[16].
- Silicones additives or coatings can **reduce uptake of water by up to 80%** compared to traditional building materials[17]**,** thus contributing to avoided degradation, **lengthening the operational lifetime of the material treated by a factor of two or more**[18].
- Silicones **improve building energy efficiency.** For example: A building facade with structural glazing/ insulating glass units can lower the U-value[19] by 0.2 W/(m^{2}K), subsequently reducing demand for heat, and energy (Wolf, 2010)[20]. Studies have also shown that impregnating a brick facade with silicone additives rather than using alternative masonry water repellent techniques emits 13 times **less GHG emissions**[21].

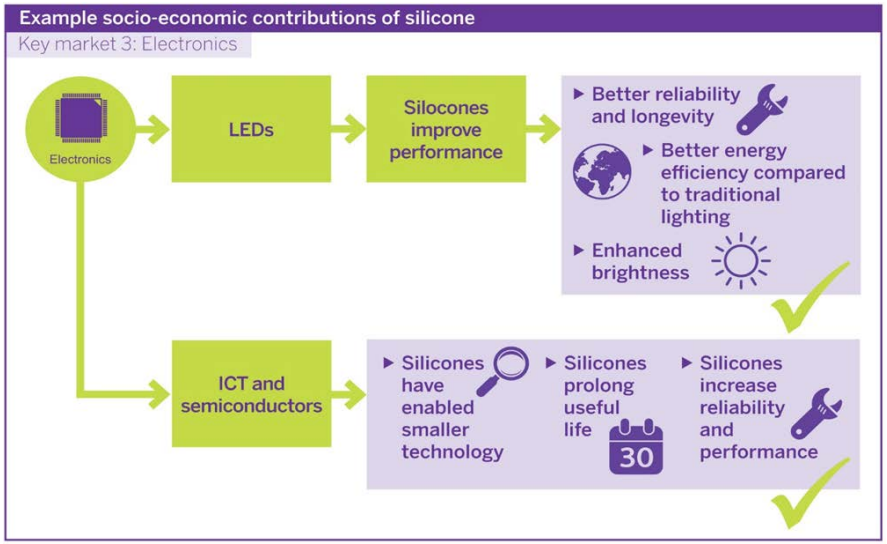


[16] Dow Corning (n.d.) When you renovate, protect your building with proven weathersealing solutions. http://www.dowcorning.com/content/publishedlit/63-1193.pdf?wt.svl=Construction_Personas_RD1
[17] Based on consultation response from the GSC survey
[18] Brandt et al (2012) Si-Chemistry Carbon Balance. Greenhouse gas emissions and abatement related to the total markets of silicones, siloxanes and silane products in Europe, North America and Japan.
[19] U-value is the measurement of heat loss signifying heat lost in watts (W) per square metre of material.
[20] Wolf, A. (2010) Contributions of silicone technology to sustainable architecture. Dow Corning Construction Solutions. http://www.dowcorning.com.cn/zh_CN/content/publishedlit/63-1177-01.pdf
[21] Ibid.

Electronics

In electronics, the uses of silicones has been examined in Light Emitting Diodes (LEDs), in Information Communication Technology (ICT), and in semi-conductors, mainly as encapsulants. The LED market in 2011 was valued at ¥1,494 billion, and it is predicted to grow to ¥5,105 billion by 2020. Asia accounted for almost 80% of the LED market (¥1,211 billion), with Japan being the largest supplier of LEDs (30% share). The global trade in ICT goods was worth ¥179,000 billion in 2011. The global semiconductors market was valued at ¥36,537 billion in 2013, with Korea being the second largest market. It is predicted that the semiconductor market will continue to grow to approximately ¥45,910 billion by 2018.

- The use of silicones in LEDs devices results in **lower optical losses, increased brightness** and **duration**, and greater **protection and reliability**, thus contributing in reducing replacement, maintenance costs and solid waste generation.
- Silicones contribute to **energy efficiency improvements** in lighting**.** LEDs lights currently use **90% less energy** and could save almost ¥ 1,400 billion and reduce 60 million metric tons of GHGs being emitted annually[22].
- In ICT, Silicones have contributed to **greater connectivity and mobile working and enhanced power of electronics, increasing businesses productivity**. The processing power and storage capacity of mobile devices are now 100 times more capable than PCs of 20 years ago[23].
- **Silicones prolong the useful life of electronic equipment**, by contributing to reduced cleaning, maintenance, operational and replacement costs. By **increasing the reliability and performance of semiconductors**, silicones contribute to increased product life-time and reduced maintenance needs of the electronic devices that use them[24].

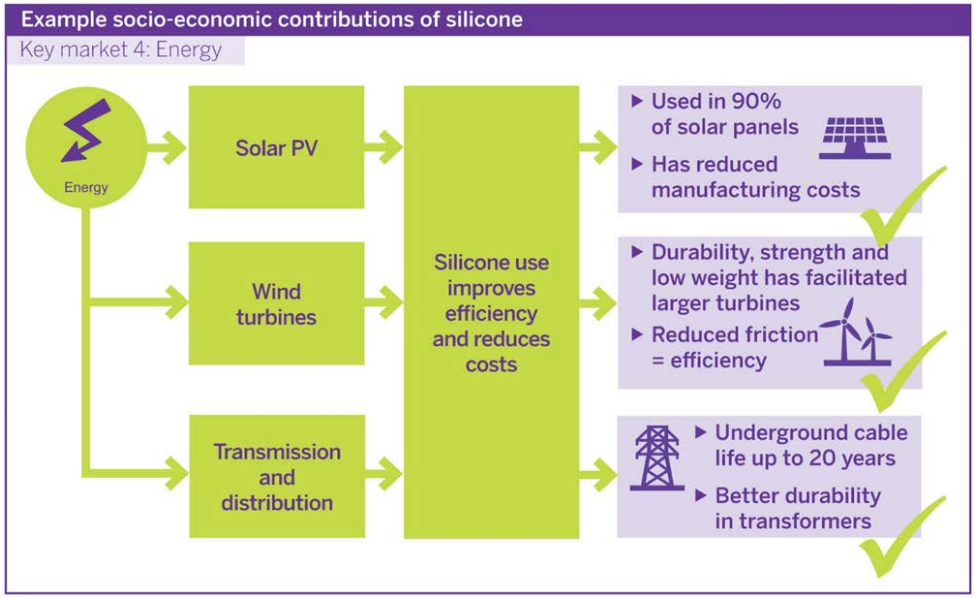


[22] http://www.bbc.co.uk/news/technology-22106718
[23] http://peter.a16z.com/2014/10/28/meteor/
[24] Dow Corning (2014) Silicones: Electronics Changing the Picture of Electronics Worldwide (https://www.dowcorning.com/vi_VN/content/vietnam/ces_electronics.pdf)

Energy

In 2015 approximately 180 Gigawatt of solar photovoltaic (PV) capacity had been installed (IRENA, 2015a), with Asia having the second largest installed capacity (30% share). In China alone, capacity is planned to increase from 20 GW to 100 GW by 2020 (Deutsche Bank, 2015). By 2030, it is expected that the **solar energy** market will reach ¥598,000 billion of cumulative revenue, with growth largely driven by decreasing costs, amongst other factors. In 2013, global installed capacity from wind energy was 318 GW (2.9% of the global electricity production). 36% of this is installed in Asia, mainly driven by China. The wind energy sector employs more than 1 million people globally (IRENA, 2015a), and its estimated global economic impact is of ¥20 billion. Demand of **wind energy** is increasing, especially for offshore wind energy (GWEC, 2014).

- Silanes are also essential for the production of solar grade silicon which requires silicon of high purity. Without silanes, it would not be possible to produce silicon of sufficient purity for solar grade silicon. Around 90% of solar (photovoltaic) cells are based on silicon. They aid **durability and functionality,** providing durable bonds and seals alongside electrical insulation.
- Silicones provide a wide range of properties (see section 2) at a relatively low cost. Hence, they provide high performance while at the same time significantly **contributing to the unit cost reductions** witnessed in the sector.
- **Silicones have facilitated larger wind turbines with greater energy potential.** Average blades manufactured between 1980 and 1990 were 17 metres across and generated 75KW of energy; this compares to 100 metres and 3,000KW in 2010.
- By reducing friction between components, silicone lubricants **reduce wind turbine maintenance costs and maximise energy efficiency**. These efficiency gains may increase energy generation by up to 8% per turbine[25].

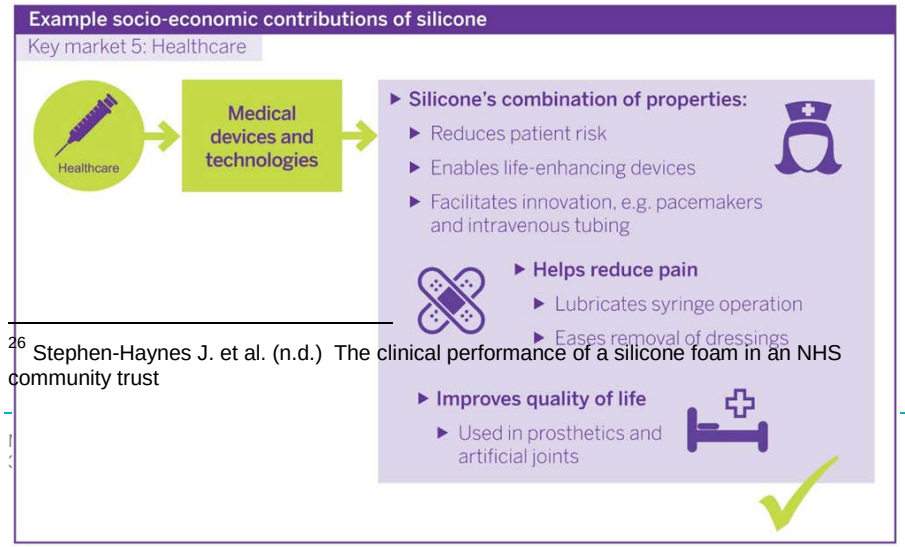


[25] http://www.dowcorning.com/content/news/Silicones_Make_Wind_Energy_a_Breeze.asp

Health care

The ten largest global medical device markets comprise nearly three quarters (73%) of the total market of ¥28,622 billion. Japan is the second largest market (10%, ¥3,874 billion). The **medical device sector** is highly innovative: on average, companies spend 12% of their revenue on R&D. In terms of employment, over one million people are employed in this sector globally. The global **pharmaceutical industry** generated almost ¥115,717 billion in 2011 from sales revenue, ¥29,720 billion of which was in Asia. As in the medical device sector, Japan is the second largest market (¥15,229 billion). The ten largest markets employed almost 2.4 million people; China alone employed 1.6 million people (66% of total). In terms of innovation, some $135 billion (¥ 16,140 billion) (more than 10% of average sales revenue) is spent on R&D per year.

- Silicones **reduce patient risk, enable life enhancing medical devices and contribute towards various innovations,** such as pacemakers', cochlear impacts, and wearable sensors. Their particular characteristics include biocompatibility and bio-durability. They are resistant to bacteria and hence are easily sterilized, enhancing the safety of patients.
- Where used as a lubricant on needles and syringes, silicones **reduce pain on entering the skin and reduce drag on the syringe barrel.** Silicones' adhesion properties also contribute to **improvements in safe wound management**.
- It has been found that silicone dressings can reduce pain on removal, reducing anxiety alongside faster healing. According to one study Silicone dressing increased wear time of the dressing by an average of 84%[26], leading to **cost savings in public health services**.
- Silicone components used as prosthetics or artificial joints can mimic textural properties of bone, cartilage and soft tissue increasing patients' self-esteem, mobility and quality of life. It also results in fewer patient visits, reducing resource costs[27].
- Silicone antifoam additives are an **important suppressant of foam/gas in stomachs** and are thus used in many antiflatulent/ antacid products[28].
- Silicones improve spread ability, emolliency and lubrication, resulting in **better usage of medication**.



[26] Stephen-Haynes J. et al. (n.d.) The clinical performance of a silicone foam in an NHS community trust

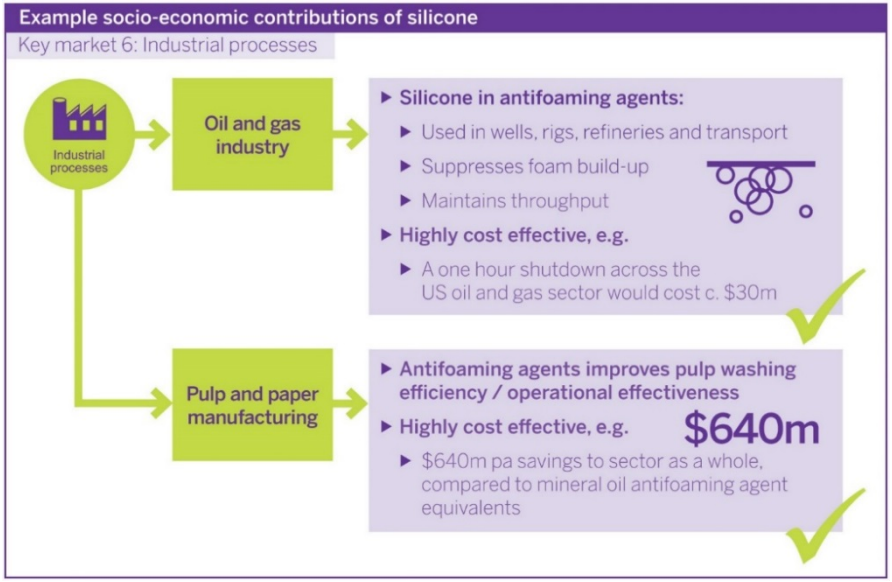
[27] http://kingslicensing.kcl.ac.uk/technology/18244

[28] Dow Corning (2006) Silicones in Pharmaceutical Applications. Part 4: Silicone Antifoams and Silanes

Industrial processes

Whilst there are a huge range of applications in this sector, oil and gas extraction and refining is one of the biggest industrial sectors in the world. Global 'primary energy consumption' was 12,928 million metric tons of oil equivalent in 2014, 56% of which was based on oil and gas. Among other industrial processes, pulp and paper produced around 580 million metric tons. In Asia, China accounts for by far the largest volumes with 110 million metric tons, but like South Korea, the majority of this is paper manufacturing rather than pulp activities. Japan accounts for just over 35 million metric tons.

- Silicones are the most widely used **antifoam/ defoaming agents** in the oil and gas industry[29]. They contribute to **maintaining throughput and production** in wells, rigs, refineries and in the transportation of oils. They also **deliver "major savings"**[30], for instance by preventing oil leakage and downstream equipment damage[31].
- Industry consultation has indicated that a loss of silicone is likely to have further operational implications (and thus higher costs), such as: **loss in efficiency of drilling mud, increased presence of foam/ bubbles in gas/ oil separation, storage and oil piping.**
- By preventing and reducing foams that build up during pulp and paper manufacturing, silicones contribute to **greater production efficiency**, and they may also **reduce water use**.
- Silicone antifoam/ defoamers are typically added at doses significantly below the volumes typically required when using certain alternative agents, evidence suggests **between 300% and up to 900% less additive may be required.**
- A 1993 study estimated the cost savings of using silicone antifoams in the pulp and paper industry compared to mineral oil antifoaming agents. Extrapolating the findings, if 100% of the industry used silicone anti-foams, the **savings would be over ¥77 billion** compared to a scenario where only mineral oil anti-foams are used[32].



[29] "Foam control", chapter in Production Chemicals for the Oil and Gas Industry, Malcolm A. Kelland CRC Press 2009 (http://www.crcnetbase.com/doi/abs/10.1201/9781420092974-c12)

[30] http://www.akersolutions.com/Documents/Drilling%20Technologies/Process%20Systems/Processing_solution_brochure.pdf

[31] Given the scale of the industry and the volume of throughput, even a negligible interruption in production could have significant costs: a one hour shutdown across the sector would result in losses of €26.9 million, whilst a negligible loss of efficiency would result in losses of €24.2 million.

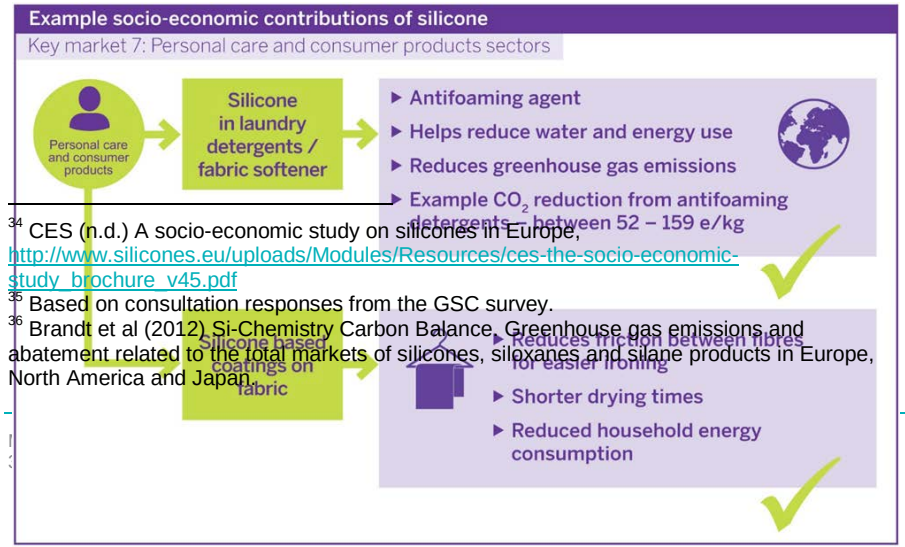
[32] Burke (1993) "New Product Developments in Antifoams Utilizing Silicone Chemistry Can Improve Economics, Washing Efficiency and Reduce Deposition Problems," 1993 PacWest Conference Proceedings. http://www.forestindustries.se/documentation/statistics_ppt_files/international/global-paper-production-by-region

Personal care and consumer products

In 2013, global sales in the **personal care sector** (skin care, hair care, colour cosmetics, fragrances, oral care, bath and shower, men's grooming, deodorants, sun care, among others) were ¥54,000 billion. Demand is growing in Asia Pacific, and per capita spending on products in the personal care sector is greatest in Japan (¥ 23,176). In terms of employment, in China for instance around 2.5 million jobs are supported by the industry (PWC, 2008). In 2013, the **household care market** size totalled ¥17,000 billion[33].

[33] This figure includes Brazil, China, the UK and U.S.

- Silicones are common in high-end personal care products. The use of silicones in the personal care and home care sector is estimated to represent ~26% added value in financial terms (based on the European market)[34]. Product characteristics include a "smooth and silky feeling" on the skin and hair, **improved spreadability, low skin irritation** whilst being odourless and colourless.
- Silicones contribute to **energy savings in personal care product manufacturing** since a stable emulsion is achieved in a short time and at room temperature[35].
- In various products, the 'film-forming' properties of silicones substantively increase wash-off resistance reducing the number of applications needed and hence providing **savings for the final consumer.**
- Silicones help **reduce household water and energy use**. In laundry detergents for instance, **reductions in greenhouse gas emissions** resulting from antifoaming detergents are estimated to be **between 52 kg CO_2e/kg and 159 kg CO_2e/kg** (Brandt et al., 2012)[36].
- Silicones reduce friction between fibres meaning **less ironing,** and **coatings result in shorter drying time, reducing household energy consumption** (for instance in the UK reduced usage of one tumble dryer can have energy savings of up to 0.9 TWh equivalent to 0.4 Mt CO2 p.a.)
- **Silicones improve the efficiency of the active cleaning agent, reducing the amount of detergent needed and the temperature of the washing cycle,** subsequently reducing energy use.



[34] CES (n.d.) A socio-economic study on silicones in Europe, http://www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study_brochure_v45.pdf

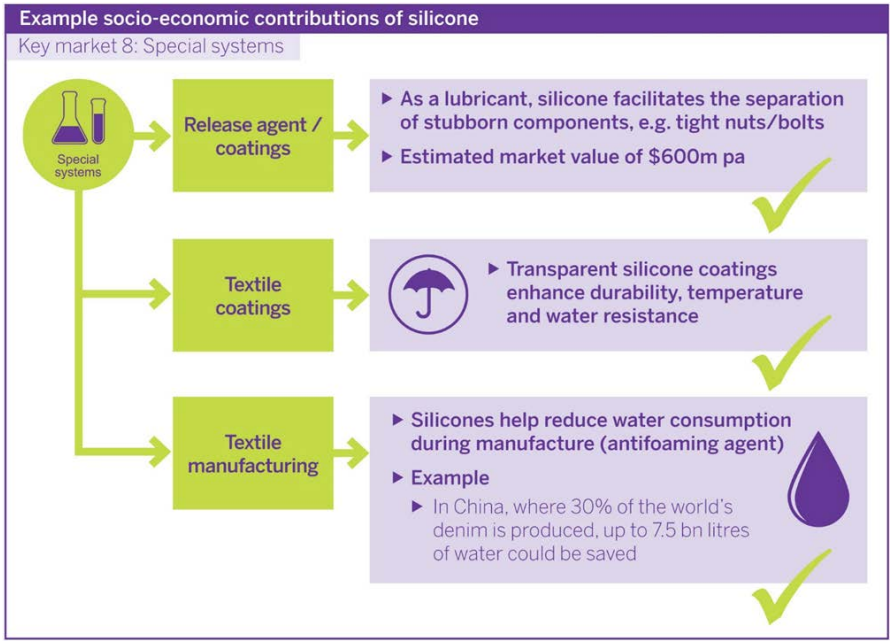
[35] Based on consultation responses from the GSC survey.

[36] Brandt et al (2012) Si-Chemistry Carbon Balance. Greenhouse gas emissions and abatement related to the total markets of silicones, siloxanes and silane products in Europe, North America and Japan.

Special systems

A number of processes fall within the category of 'special systems'. Among these, the **release liner market** is a key product within the packaging industry with an estimated global economic value of ¥1,200 billion as of 2014. The global output for the **textile industry** had an estimated worth of ¥113,000 billion in 2012, of which Chinese industry was responsible for 56% (¥63,000 billion). In 2010, the global **printing market** had a market value of ¥94,000 billion.

- **Silicone coatings have unique properties**, including resistance to high-temperature, flame, chemicals, moisture, water, abrasion, bacteria, and protection from UV rays and weather more generally as well as stability in high and low temperatures.
- Within the €9 billion (**¥1,200 billion)** release liner market, **silicone release coatings for liners have an estimated market value of ¥72 billion**[37]**.** Silicone polymers are used for ~70% of release liners and provides various performance characteristics due to their low surface tension and hence low friction[38].
- In textiles and clothing **transparent silicone coatings contribute to enhanced durability, dirt, temperature and water- resistance**. The durability offered by silicone coatings are particularly beneficial for outdoor clothing[39].
- In the textile and clothing industry silicones are used as process aids which **increases efficiency and reduces costs**. Silicone softening technology can **reduce water consumption** in the finishing stages of textile production by 30-50% (meaning ~15 litres of water per pair of jeans).
- In agrochemicals, adjuvants can improve foliar absorption of the applied product by up to 80%. Silicone-based agricultural adjuvants have the **fastest wetting time** compared to other adjuvants and have the **lowest surface tension, enhancing the performance of agrochemicals and reducing the volumes needed**[40].
- Silicones also **facilitate high speed printing techniques, increasing production efficiency and reducing costs**.



[37] Based on consultation response from the GSC survey
[38] Gordon et al. (1998) Silicone release coatings: A closer look at release mechanisms. Dow Corning Publication. http://www.dowcorning.com/content/publishedlit/26-016.pdf
[39] Based on consultation responses to the GSC survey.
[40] Barnhart, S. (2000) Agricultural Spray Adjuvant Technology – Sorting out the adjuvant puzzle (presentation).

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