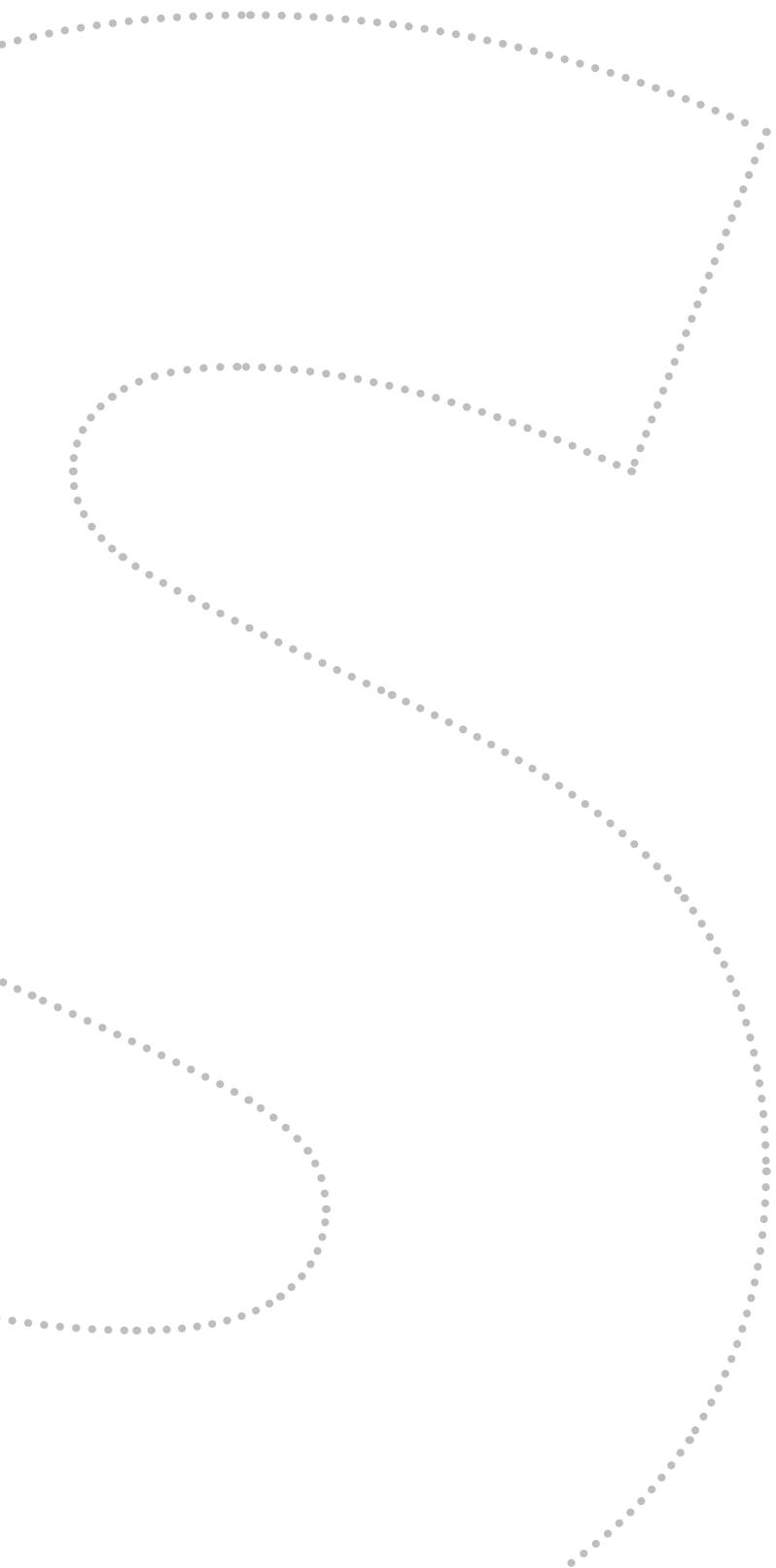


Si / Smart. Sustainable. Surprising

# THE SOCIOECONOMIC IMPACT OF THE SILICONES INDUSTRY IN EUROPE



- SILICONES EUROPE



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# **THE SOCIOECONOMIC IMPACT OF THE SILICONES INDUSTRY IN EUROPE**

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# KEY FINDINGS — EUROPE

## 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 **European society** (EU 28, Norway Switzerland and Turkey). Further summary reports are available for the Americas and Asia, 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 industry member companies, silicones manufacturing is an €10 billion global industry, with 2,122,000 metric tons of formulated silicone products sold. Sizable manufacturing operations are located in Europe. Total sales of silicones products to Europe account for €3 billion and around 590,000 metric tons. These sales created a further €13.5 billion of added value along the supply chain across Europe. The majority, just under €3 billion was created via sales to Germany, but with substantial added value created via sales to France, the UK and Italy (around €1 billion each).

Revenues generated by silicone sales comprise significant proportions of total company revenue accounting for 28% on average, indicating the importance of these product lines to several major companies. The silicones 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 €419 million, 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, 10,000 are directly employed in Europe. Collectively it is estimated that these employees earn €0.8 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 the supply chains. It is estimated that around 1.7 million people may be employed in economic activities that in some way interact with silicones products, whether formulating, distributing, integrating silicones products into larger components, or selling products that contain silicones across Europe.

## THE SILICONES SUPPLY CHAIN AND ‘ENABLING CHARACTERISTICS’

Almost 590,000 metric tons of products containing silicones were sold to eight “key markets” in Europe. These markets are summarised below, alongside a summary of the wider benefits that silicones help deliver in these products.

### •••• TRANSPORT

In this sector, 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. Better electrical insulations and water resistance of electrical circuits allow start/ stop systems that help to significantly reduce fuel consumption and emissions. They help reduce weight and friction alongside other performance characteristics (e.g. heat/oil/fuel 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 €202 per car., every year. Around 35,000 metric tons of products were sold in Europe, with a direct sales value of €298 million.

### •••• CONSTRUCTION MATERIALS

A total of 194,000 metric tons of silicone product were sold to the sector in Europe with sales of €562 million. Products comprised a wide range of sealants, adhesives and protective coatings often developed with specific characteristics. They provide a strong durable, weather and UV resistant seal, with excellent adhesion to a range of materials. Sealants are used extensively in building construction and maintenance, particularly high rise glass facades and enabling 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 hydrophobic properties help silicone coatings protect external walls from weather damage.

#### •••• ELECTRONICS

A total of 9,000 metric tons of silicone products were sold to the electronics market, with sales of €76 million; the highest value silicone product, on average, across all sectors. In this sector silanes are essential for the production of electronic grade silicon. 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. Also used to insulate wiring, silicones have a series of specific properties making them particularly suitable. They provide excellent electrical insulation properties alongside 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 14,000 metric tons of silicone products were sold to the energy market, with sales of €76 million. 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 11,000 metric tons of product was sold to the healthcare market generating sales of €118 million; 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 sterilisation. 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 and 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

This is the largest single market accounting for over 172,000 metric tons of silicone product with a sales value of €616 million. 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 79,000 tons of silicone products were sold into the sector, with sales of around €407 million. 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, helping 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 74,000 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 €374 million.

# INTRODUCTION

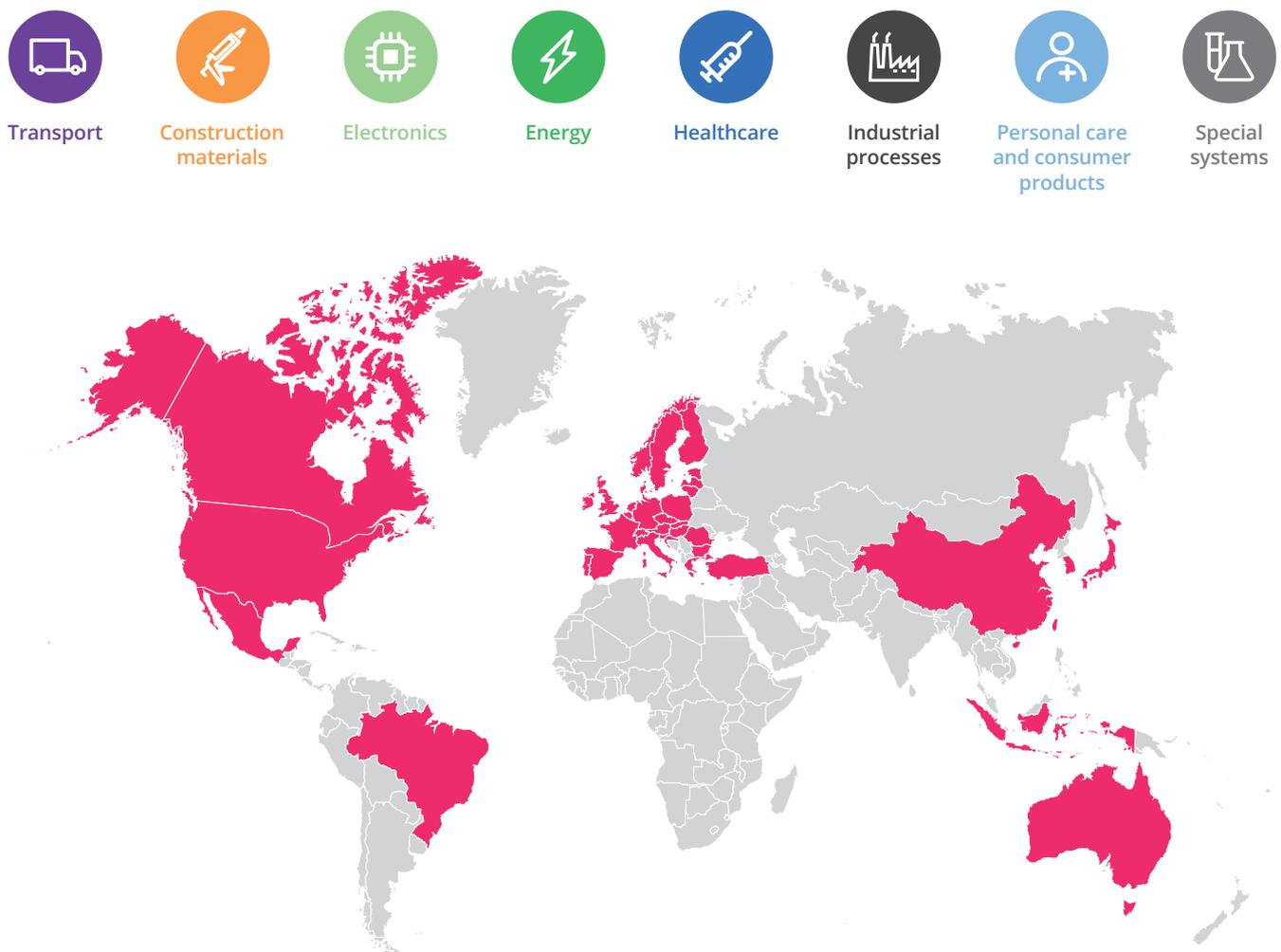


In November 2014, Amec Foster Wheeler was commissioned by the Global Silicones Council (GSC) to carry out an independent socioeconomic evaluation (SEE) of the contribution made by the silicones industry to the global economy. The assessment focuses on the benefits of the industry itself, in terms of turnover and economic output, employment, contribution to international trade, economic competitiveness and innovation, and 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'<sup>1</sup>, and three 'global regions'; Europe, the 'Americas' and Asia<sup>2</sup> 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 **European society**. This is defined as the EU 28, plus Norway, Switzerland and Turkey. Further regional summary reports are available for the Americas and Asia 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<sup>3</sup>.

Figure 1 — Scope of the study (Countries and Markets)



1 — The key markets analysed are: transportation, construction, electronics, energy, health care, 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); '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.



## 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 socioeconomic 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 and references are in the global report.*



## TRANSPORT

### IMPORTANT USES

- 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 vessel 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.

### KEY PROPERTIES

- 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. Through their use in air bag coatings, they **contribute to reductions in road fatalities**. They also enable the development of advanced components design.
- 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 above.



## CONSTRUCTION MATERIALS

### IMPORTANT USES

- 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, in sealants for joints in paving, decks and concrete slabs. Silicone forms an essential part of the formulation.
- Silicone sealants are used in exterior applications for **weather-sealing of facades, structural glazing, and perimeter sealing of windows and doors and expansion joints**.
- 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.

### KEY PROPERTIES

- Silicone sealants and adhesives bond with a variety of materials so can be used in a variety of situations. 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**.
- Because of 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.



## ELECTRONICS

### IMPORTANT USES

.... Silanes, the starting material in the production of silicones, can be functionalised 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 also 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 (e.g. mobile phones, computers, and 'tablets')**.

.... 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.

### KEY PROPERTIES

.... Silicones are stable over a wide temperature range from -60C 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 as well as 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, and ensuring the durability of devices. This is critical to ensure long-term stability and performance in a large numbers of electrical products**.



## ENERGY

### IMPORTANT USES

.... Silicones are used in a variety of application in the energy sector. As in electronics, **silanes are essential for the production of solar grade silicon which requires high purity**.

.... Silicones provide good electrical insulation and serve as a stable base for conductive adhesives that are used in **solar panels where around 90% of solar (photovoltaic) cells are based on silicon**. 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**.

### KEY PROPERTIES

.... The **temperature resistance** of silicones range from -60°C to +180°C, while their low reactivity towards 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 interruption in electricity supply**.



## HEALTHCARE

### IMPORTANT USES

••• 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 component products 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.

### KEY PROPERTIES

••• 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 biodegradability 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. They provide chemical stability, durability and elasticity.**

••• 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

### IMPORTANT USES

••• 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.**

••• Silicone 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.

### KEY PROPERTIES

••• 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

#### IMPORTANT USES

- 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 detergents.**
- Silicones are also used in various components in **consumer products, including cooking utensils, sporting goods, baby and infant products, and furniture and bedding, among others.**

#### KEY PROPERTIES

- As a component of a consumer good, **silicones have a long product life with good durability, and they are resistant to bacteria.**
- 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

#### IMPORTANT USES

- 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 product but 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.**

#### KEY PROPERTIES

- 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.**



## THE SILICONE INDUSTRY — KEY FIGURES

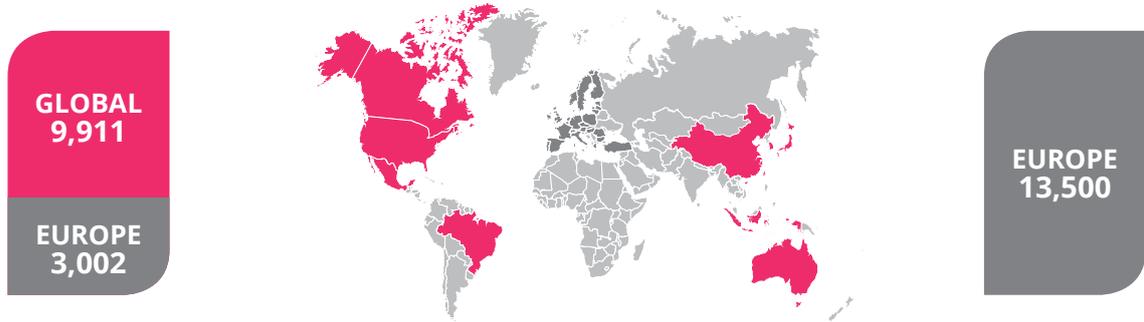
*This section summarises the direct and indirect social and economic effects from the manufacture and sale of silicones in Europe. The data are presented graphically (Figure 2), with further commentary overleaf<sup>4,5</sup>.*

Figure 2 — Key figures on the European silicone industry

**TURNOVER / REVENUE**

Annual turnover of silicones by global regions (€ million, 2013)

Downstream added value



**DIRECT EMPLOYMENT**

Number of employees by regions (2013)

**EUROPE — 10,000**  
TOTAL FOR REGIONS — 29,000



**EMPLOYMENT ALONG SILICONE SUPPLY CHAINS**

Number of employees by regions (2013)

**EUROPE — 1.7 m**  
TOTAL FOR REGIONS — 14 m



**GLOBAL INVESTMENT IN RESEARCH AND DEVELOPMENT (R&D)**

Research and development expenditure related to silicones (2013)

**PERCENTAGE OF TURNOVER**

**4.2 %**  
(€419m)



**THE SILICONE SUPPLY CHAIN — SALES TO KEY SECTORS**

Downstream applications of silicones (tons and values, 2013)

	Transport	Construction materials	Electronics	Energy	Healthcare	Industrial processes	Personal care and consumer products	Special systems	<b>TOTAL</b>
<b>TOTAL QUANTITY SOLD (000S OF TONNES)</b>	35	194	9	14	11	172	79	74	<b>588</b>
<b>TOTAL VALUE OF QUANTITY (€M)</b>	298	562	125	76	118	616	407	374	<b>2,576</b>

4 — All data in this section relates to 2013 unless otherwise stated. Global value data is expressed Dollars and Euro. The exchange rate used is \$1 = €0.90 (European Central Bank Official exchange rate, average January – May 2015).

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 global silicones industry member companies, it generates revenue/turnover of €10 billion annually. Just under a third of the turnover (30%) came from silicone products sold in Europe (around €3 billion).

•••• Beyond silicones, GSC members manufacture several different product types, with revenues from all products of over €35 billion. In Europe, silicones comprise significant proportions of total company turnover accounting for 28% of the aggregate company turnover amongst the GSC members.

## 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 Europe directly employ 40,000 people in total. Around 10,000 of these are directly related to silicone product lines which constitutes 36% of total silicone related employment (note this excludes indirect employment along supply chains).

•••• In terms of gross salaries, European employee's related to silicone product lines earned a total of around €0.8 billion, which supports widespread indirect economic activity in the domestic economies from the expenditure of employees on housing, recreation, and goods and services<sup>6</sup>.

## INVESTMENT IN RESEARCH AND DEVELOPMENT (R&D)

•••• The silicones 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 some €0.4 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<sup>7</sup> on each of the key sectors identified in section 2.

### •••• TRANSPORT

This includes car and automotive components manufacturers, aircraft and aviation components manufacturers, military and ship builders. In Europe, 34,600 metric tons were sold for a value of around €300 million.

### •••• CONSTRUCTION

This includes sealants and adhesive producers and distributors, DIY commercial suppliers, construction firms and contractors. In Europe, 194,300 metric tons were sold for a value of €562 million.

### •••• ELECTRONICS

This category covers a large range of applications, including semi-conductors, automobile electronics, computers, LEDs amongst others. It includes component manufacturers, device designers and manufacturers. Some 9,300 metric tons were sold in Europe worth €125 million.

### •••• ENERGY

Applications in this category relates 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 13,800 metric tons were sold in Europe worth €76 million.

### •••• HEALTHCARE

This category includes device manufacturers, public health care providers and pharmaceutical firms. A total of 11,300 metric tons were sold in Europe (€ 118 million).

### •••• INDUSTRIAL PROCESSES

Among this category we find oil and gas refineries and plants, offshore rigs, energy companies and various industrial manufacturers. Sales in Europe amount to 172,400 metric tons worth €616 million.

### •••• 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. Europe accounts for 79,200 metric tons, with a sales value of €407 million.

### •••• SPECIAL SYSTEMS

This includes various applications in the textile industry; in adhesives and coatings and agrochemicals. A total of 73,700 metric tons were sold into Europe, for a sales value of €374 million.

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 are 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.

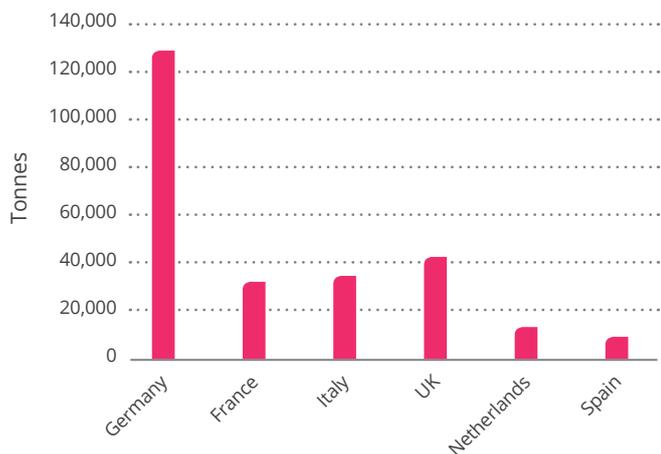
# SALES OF SILICON IN EUROPE

*This section provides further information on products containing silicones that were sold in Europe. Note that given the large number of countries, data was collected on sales to the largest European Countries rather than sales to every country. It draws on data from the GSC members; further volumes may be manufactured by non GSC members in some regions. This limits the detail that can be given, due to confidentiality, but illustrates the most important countries and sectors. The data relate to products sold by the manufacturers, but at this late stage products contain various additives in addition to silicones, which differ depending on the product/ key market concerned.*

Total global sales is more than 2 million metric tons generating almost €10 billion revenue. Total European sales are around 590,000 metric tons generating a revenue of approximately €3 billion.

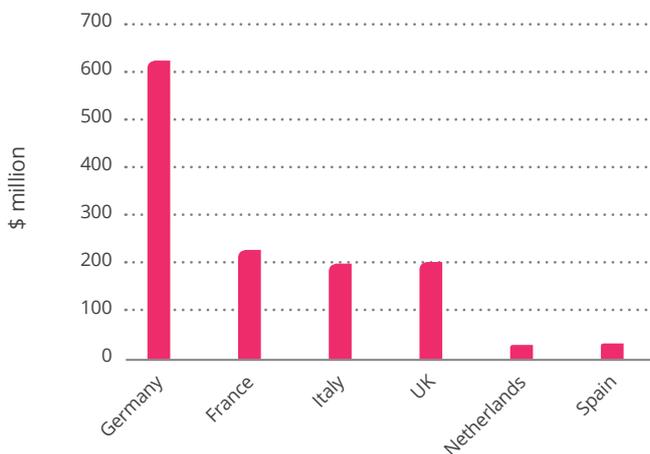
**Figure 3** and **Figure 4** below show sales volume and values for the largest markets in Europe. Data are shown only for those Member States where three or more companies responded to the questionnaire. Overall, Germany is the largest purchaser of silicones (38%, 129,800 metric tons with sales value of over €600 million). Sales to Germany are approximately three times the volume than the next largest country, the UK (13%, 42,700 metric tons). Other notable purchasers include France (11%, 32,000 metric tons) and Italy (11%, 35,200 metric tons).

**Figure 3 — Silicones sales volume in largest markets: Europe (metric tons, 2013)**



Source: Amec Foster Wheeler GSC Survey, May 2015. Note that the survey requested data on both total and the largest five European markets, which differed somewhat between respondents.

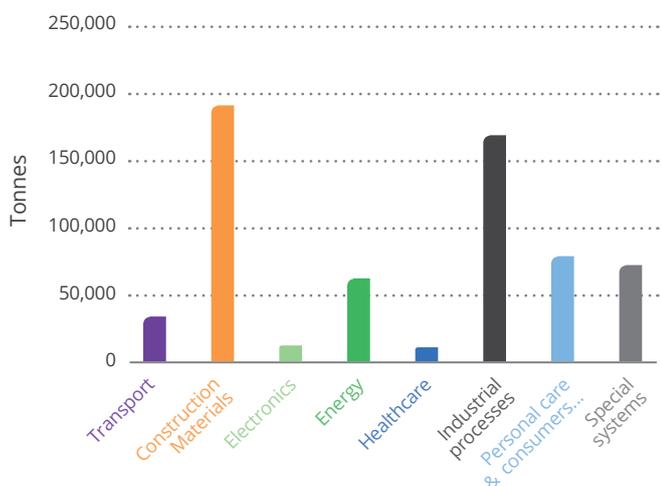
**Figure 4 — Silicones sales value in largest markets: Europe (\$ million, 2013)**



Source: Amec Foster Wheeler GSC Survey, May 2015. Note that the survey requested data on both total and the largest five European markets, which differed somewhat between respondents.

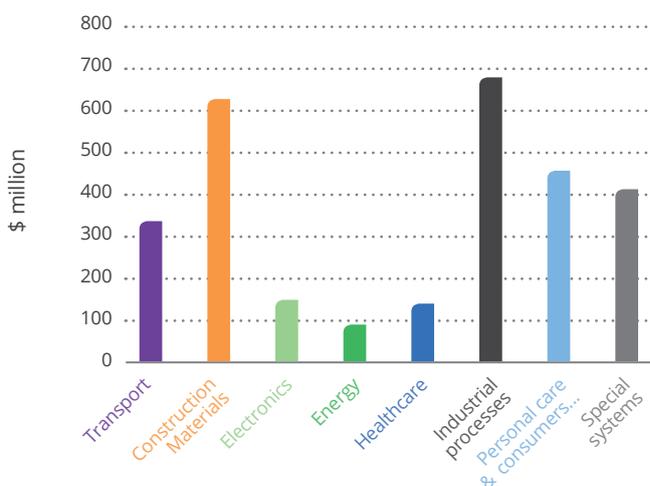
A summary of the volumes and values of silicones purchased in each sector within Europe is shown below in **Figure 5** and **Figure 6**. The construction sector is the largest purchaser of silicone products, accounting for almost 200,000 metric tons, or 33% of all silicone products purchased in Europe during 2013, with a combined sales value of approximately \$600 million (€560 million). The second largest sector by sales volume is the industrial processing sector (172,000 metric tons, 29%), however, this sector is largest by sales value \$700 million (€615 million), suggesting higher value products, on average, in this sector. Sales to personal care and consumer products and to 'special systems' are similar in terms of volume, each accounting for 13% and sales of around \$450 million (€ 400 million) in each case. Comparing sales volume and value indicate that silicone products sold to the transportation, electronics and healthcare sectors are the higher value.

**Figure 5 — Silicones sales in key sectors Europe (metric tons, 2013)**



Source: Amec Foster Wheeler GSC Survey, May 2015. Note that the survey requested data on both total and the largest five European markets, which differed somewhat between respondents.

**Figure 6 — Silicones sales in key sectors Europe (\$ million, 2013)**



Source: Amec Foster Wheeler GSC Survey, May 2015. Note that the survey requested data on both total and the largest five European markets, which differed somewhat between respondents.

# EUROPE SECTOR ANALYSIS

*The paragraphs below provide further details on sales by silicone manufacturers to downstream users, within 8 key sectors and large Member States' markets in Europe. Where there are less than three sets of data for a 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 Member State, within the applications discussed.*



## TRANSPORT

••• The transportation sector in Europe in 2013 registered 34,600 metric tons of silicone-based products, with a value of € 298 million.

••• Germany is the largest purchaser of silicone products accounting for 19% (6,700 metric tons) of the sales volume, a value of €80 million. This is likely to reflect the large automobile and aerospace manufacturing industry.

••• France is the next largest purchaser of silicones, accounting for 15% (5,100 metric tons).

••• Other important countries include Italy (3,200 metric tons) and the UK (1,500 metric tons). Spain also represents another significant purchaser of silicones in this sector.



## CONSTRUCTION MATERIALS

••• In 2013 194,300 metric tons of silicones products were sold in the construction sector in Europe, with a value of €562 million.

••• Germany dominates the European market, accounting for 31,400 metric tons (16%) of the sale volume, a value of €97 million.

••• The next largest purchaser is the Netherlands, with sales volume of 13,000 (7%) and value of €29 million.

••• Other significant purchasers include Italy (8,400 metric tons), UK (7,400 metric tons) and Spain (5,300 metric tons).

••• Together all of these countries only make up 37% of silicone products sold within the EU. Europe has a diverse market for silicone products within the construction sector with sizable volumes and values across a large number of European Countries.



## ELECTRONICS

••• The size of the market was of 9,300 metric tons of volume sold, for a total value of €125 million.

••• Germany and France each purchased 1,400 metric tons of silicones and Italy purchased 1,300 metric tons. But the value of the silicone products was much greater (60%) in Germany, reflecting use in higher value applications.

••• These four countries makes up 46% of the total silicone products purchased in the electronics sector in Europe in 2013; sizable volumes and values are sold to several European Countries.



## ENERGY

•••• In 2013 sales in the European energy sector amounted to 13,800 metric tons (€ 76 million).

•••• Major purchasers of silicone goods in this sector included France and the UK, with Germany and Italy also purchasing sizable volumes, reflecting their solar photovoltaic manufacturing industries.

•••• France accounted for 1,200 metric tons of sales (€ 6 million), while 600 metric tons were sold in the UK (€ 4.5 million).



## HEALTHCARE

•••• Sales of silicone-based products in the European healthcare sector amounted to 11,300 metric tons in 2013 (€ 118 million).

•••• Germany was the largest purchaser of silicones for the healthcare market in Europe, accounting for 3,300 metric tons (29%), and a value of €46 million.

•••• A further 800 metric tons and 900 metric tons were purchased by France and the UK respectively.

•••• Together these three countries purchased 44% of all silicone products within this sector for Europe; sizable volumes are sold within several European countries.



## INDUSTRIAL PROCESSES

•••• Total sales in Europe the sector was 172,400 metric tons (€ 616 million).

•••• Germany was the largest European market, accounting for 47,200 metric tons sold (27% of silicone products sold in Europe), with a value of €152 million.

•••• Nearly €52 million or 19,800 metric tons of silicones were sold into the UK.

•••• France and the Italy accounted for a further 9,500 and 7,300 metric tons respectively.

•••• Together these four countries account for approximately 50% of the silicone products purchased in Europe in 2013 sizable are sold within several European countries.



## PERSONAL CARE AND CONSUMER PRODUCTS

•••• 79,200 metric tons of silicones products worth €407 million were sold to the European personal care and consumer product sector.

•••• Germany is the largest purchaser of goods, accounting for 17,400 metric tons of volume sold with a value of €87 million.

•••• Italy is the next largest purchaser of silicones, with a sales volume of 9,000 metric tons and value of €50 million. Other significant users include France (8,300 metric tons) and the UK (7,600 metric tons).



## SPECIAL SYSTEMS

•••• This sector amounted to 73,700 metric tons of silicone-based products in Europe in 2013 with a value of €374 million.

•••• Germany dominates the demand for silicone products in the 'special systems' category in Europe, accounting for 21,000 metric tons sold at a value of €74 million.

•••• Around 5,700 metric tons was purchased by France, whilst Italy and UK accounted for a further 4,800 and 4,600 metric tons respectively.

•••• Unlike in other sectors, the 'special systems' displays a high degree of diversity across many of the EU member states.

## 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 integrate 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 the “Socioeconomic Study of Silicones in Europe, published by the European Silicones Centre (CES)<sup>8</sup> has been adjusted to provide a consistent regional and global estimate.

The CES study estimated downstream employment in Europe, drawing 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 chains were some 178 times the original number employed in 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 increased 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 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 Europe. Clearly 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 1.7 million people may be employed in economic activities that in some way relate to silicones products, whether formulating, distributing, integrating silicones products into larger components, or selling products that contain silicones across Europe.

**Table 3.1 — Indirect employment along silicone supply chains in Europe – (based on European data) (2013)**

	Silicone manufacturers	Formulators and Distributers	End use sales companies	Indirect companies	TOTAL
<b>SCALING FACTOR (taken from CES study)</b>	~	18.5	45.6	105.5	<b>170.6</b>
<b>TOTAL EUROPE</b>	10,000	185,000	455,000	1.05 million	<b>1.7 MILLION</b>

Source: Amec Foster Wheeler based on data from the GSC survey on direct employment. Data from a Socioeconomic 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](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

## 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 on 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 and to the total sales value across Europe as a whole. The results provide an approximate high-level estimate of downstream added value.

•••• A total of €13.5 billion (\$15.1 billion) added value was created from the sales of ‘final’ silicone products across Europe. The majority, just under €3 billion was created via sales to Germany, but with substantial added value created via sales to France, the UK and Italy (around €1 billion each).

the study was taken from the International Labour organisation (ILO) [https://www.ilo.org/ilostat/faces/help\\_home/data\\_by\\_subject?\\_afLoop=2138106775318101#%40%3F\\_afrLoop%3D2138106775318101%26\\_adf.ctrl-state%3Di432g0u8L\\_400](https://www.ilo.org/ilostat/faces/help_home/data_by_subject?_afLoop=2138106775318101#%40%3F_afrLoop%3D2138106775318101%26_adf.ctrl-state%3Di432g0u8L_400) Note that the estimates are approximate and aim to demonstrate orders of magnitude rather than precise values. Note that numbers have been rounded.

8 — [www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study\\_brochure\\_v45.pdf](http://www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study_brochure_v45.pdf)



# THE SOCIOECONOMIC VALUE OF SILICONES

*This section summarises the wider socioeconomic benefits arising from the downstream use of silicones and of products that contain silicones. This is done by evaluating two things. First, the socioeconomic 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 summarises only the key messages.*



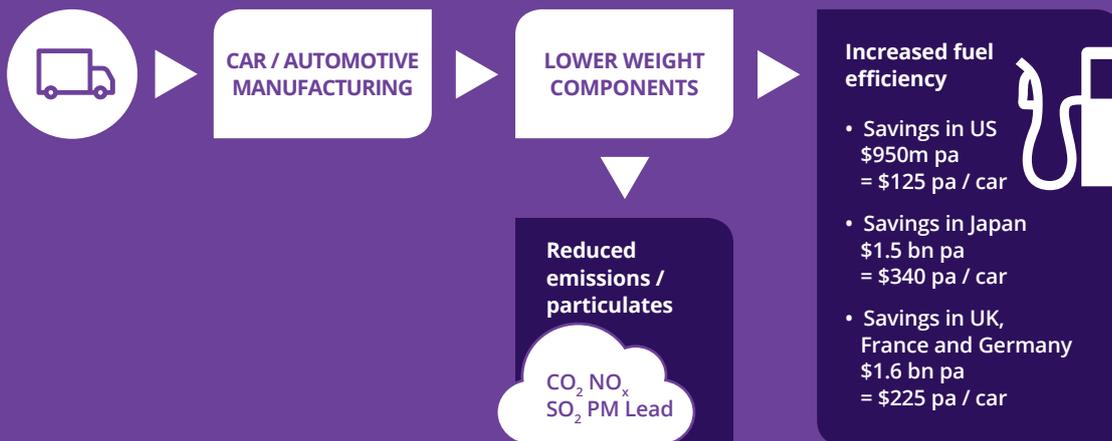
# TRANSPORT

Car manufacturing industry generated €670 billion in Europe in 2005 and directly employed 2.6 million people. Silicones are used extensively in this sector and have enabled advanced component design.

••• 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 vehicle weight reductions**, which result in **increased fuel efficiency and lower emissions** of various pollutants, mainly CO<sub>2</sub> but also volatile organic compounds, NO<sub>x</sub>, SO<sub>2</sub>, Particulate Matter and Lead<sup>9</sup> 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%<sup>10</sup>. Estimates for Germany, France and the UK based on vehicle miles driven and costs of fuel per gallon suggest cumulative total savings of €1.4 billion in annual fuel bills (€202 per car, per year).

Example of the socioeconomic contributions of silicones



9 — <https://fortress.wa.gov/ecy/publications/publications/0002008.pdf>

10 — 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

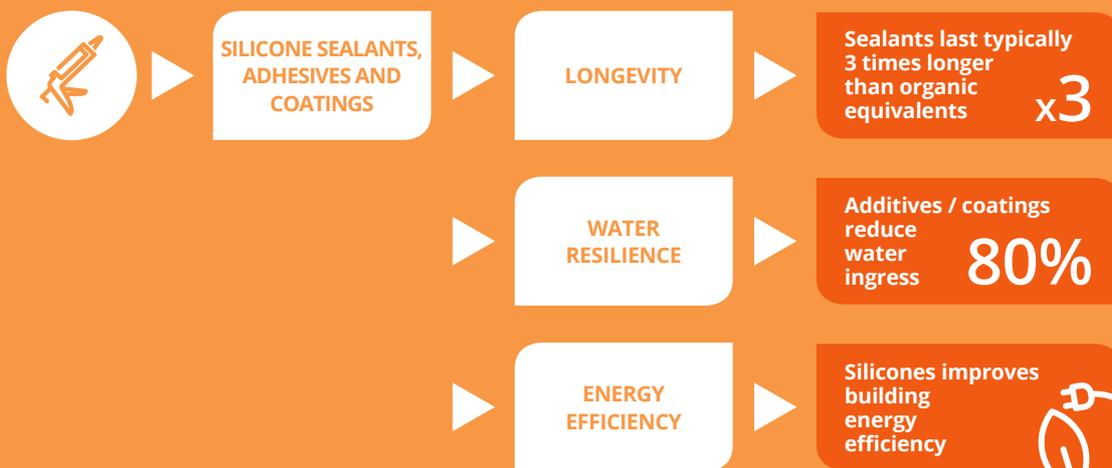
The global construction sector had a market value of €7.8 trillion in 2012 (forecast to reach €13.5 trillion by 2025), accounting for 12.2% of GDP<sup>11</sup>. In the EU, 20 million people are directly employed in the sector<sup>12</sup> (comprising ~8% of the working EU population).

••• 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 €112,000<sup>13</sup>.

••• Silicones additives or coatings can **reduce uptake of water by up to 80%** compared to traditional building materials<sup>14</sup>, thus contributing to avoided degradation and **lengthening the operational lifetime of the material treated by a factor of two or more**<sup>15</sup>.

••• Silicones **improve building energy efficiency**. For example: A building facade with structural glazing/ insulating glass units can lower the U-value<sup>16</sup> by 0.2 W/(m<sup>2</sup>K), subsequently reducing demand for heat, and energy (Wolf, 2010)<sup>17</sup>. 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**<sup>18</sup>.

## Example of the socioeconomic contributions of silicones



11 — Global Construction Perspectives and Oxford Economics (2013) Global construction 2025. A global forecast for the construction industry to 2025. [www.arcadis.com/Content/ArcadisGlobal/docs/publications/Research/Global\\_Perspectives\\_2025\\_Exec\\_Summary.pdf](http://www.arcadis.com/Content/ArcadisGlobal/docs/publications/Research/Global_Perspectives_2025_Exec_Summary.pdf)

12 — [ec.europa.eu/growth/sectors/construction/index\\_en.html](http://ec.europa.eu/growth/sectors/construction/index_en.html)

13 — Dow Corning (n.d.) When you renovate, protect your building with proven weathersealing solutions. [www.dowcorning.com/content/publishedlit/63-1193.pdf?wt.svl=Construction\\_Personas\\_RD1](http://www.dowcorning.com/content/publishedlit/63-1193.pdf?wt.svl=Construction_Personas_RD1)

14 — Based on consultation response from the GSC survey.

15 — 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.

16 — U-value is the measurement of heat loss signifying heat lost in watts (W) per square metre of material.

17 — Wolf, A. (2010) Contributions of silicone technology to sustainable architecture. Dow Corning Construction Solutions. [www.dowcorning.com.cn/zh\\_CN/content/publishedlit/63-1177-01.pdf](http://www.dowcorning.com.cn/zh_CN/content/publishedlit/63-1177-01.pdf)

18 — Ibid.

# ELECTRONICS

In the electronics sector, the use of silicones has been examined in Light Emitting Diodes (LEDs), in Information Communication Technology (ICT) and in semi conductors, mainly as encapsulates. The LED market in 2011 was valued at €11.2 billion, and it is predicted to grow to €38.3 billion by 2020<sup>19</sup>. The global trade in ICT goods was worth €1.4 trillion, with computer hardware the largest<sup>20</sup>. In 2011 global trade in ICT goods was worth €1.4 trillion. This is a 66% increase from 2000.

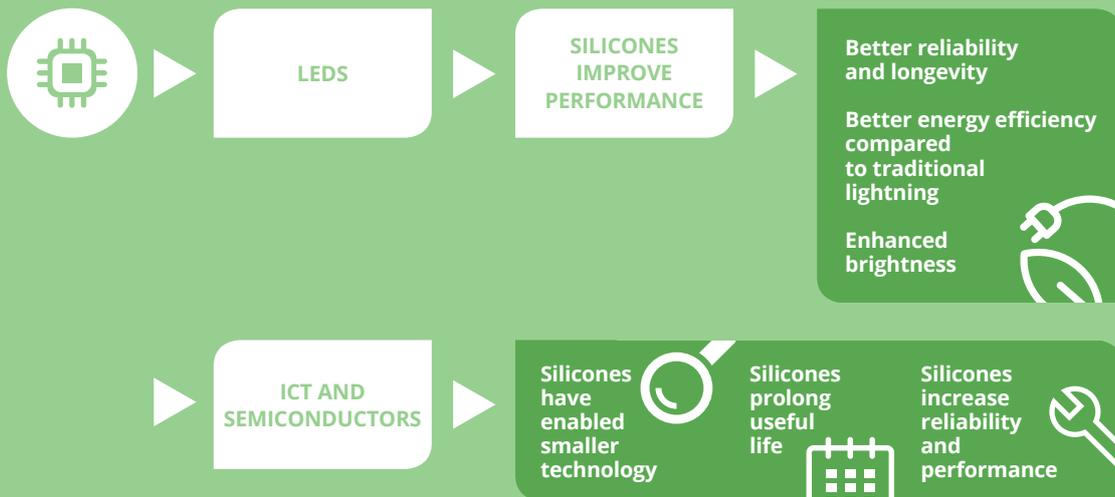
••• The use of silicones in LEDs devices results in **lower optical losses, increased brightness and duration and greater protection and reliability**, thus contributing in reducing replacement, maintenance costs and solid waste generation.

••• Silicones contribute to **energy efficiency improvements** in lighting. LEDs lights currently use **90% less energy** and could save almost €11 billion and reduce 60 million metric tons of GHGs being emitted annually<sup>21</sup>.

••• 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<sup>22</sup>.

••• **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 reducing maintenance needs of electronic devices that use them<sup>23</sup>.

## Example of the socioeconomic contributions of silicones



19 — [www.businesswire.com/news/home/20141022005546/en/Research-Markets-Global-Light-Emitting-Diodes-LED%20-%20VYKgMvViko#.VYV\\_M6NwYdU](http://www.businesswire.com/news/home/20141022005546/en/Research-Markets-Global-Light-Emitting-Diodes-LED%20-%20VYKgMvViko#.VYV_M6NwYdU)  
 20 — Note that computers' share has declined from 38% in 2000 to 30% in 2011, due to a large extent to the rising dominance of mobile communications in recent years.  
 21 — [www.bbc.co.uk/news/technology-22106718](http://www.bbc.co.uk/news/technology-22106718)  
 22 — [peter.a16z.com/2014/10/28/meteor/](http://peter.a16z.com/2014/10/28/meteor/)  
 23 — Dow Corning (2014) Silicones: Electronics Changing the Picture of Electronics Worldwide ([www.dowcorning.com/vi\\_VN/content/vietnam/ces\\_electronics.pdf](http://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)<sup>24</sup>. Europe has the largest share of global capacity (59%), driven by Germany, which has the largest installed capacity globally (36 GW). By 2030, it is expected that the solar energy market will reach €4.5 trillion of cumulative revenue. In 2013, global installed capacity from wind energy was 318 GW, comprising 2.9% of the global electricity production. Around 38% of installed capacity is in Europe, driven by Germany and Spain, but also Italy, France, the UK and Denmark. Demand of wind energy is increasing, especially driven by offshore wind energy (GWEC, 2014).

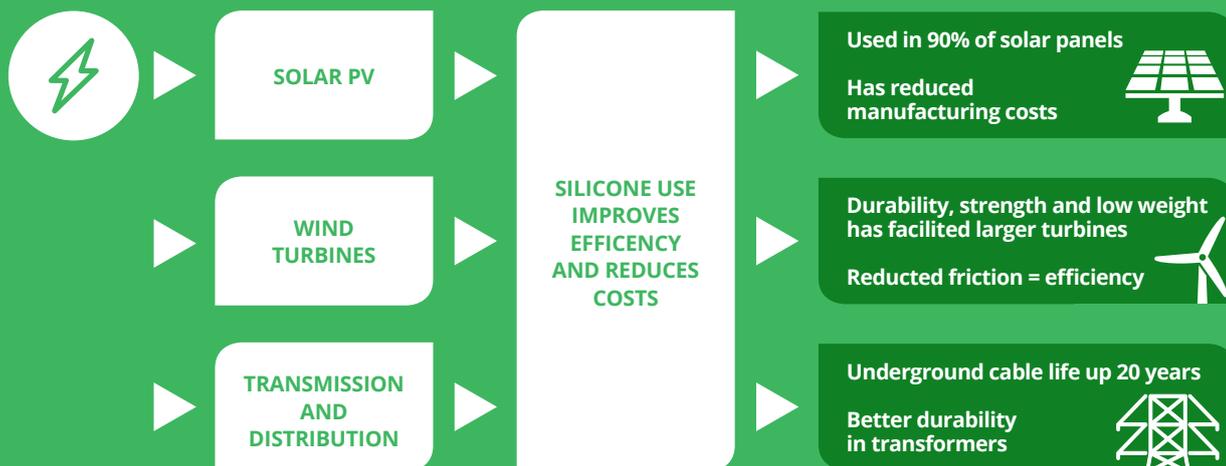
••• Silanes are also essential for the production of solar grade silicon which requires silicon of high purity. Without silanes, it would not be possible to produce silicon of sufficient purity for solar grade silicon. Around 90% of solar (photovoltaic) cells are based on silicon. They aid **durability and functionality**, providing durable bonds and seals alongside electrical insulation.

••• Silicones provide a wide range of properties (*see earlier section*) 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<sup>25</sup>.

## Example of the socioeconomic contributions of silicones



24 — IRENA (2015a) Renewable Energy and Jobs Annual Review. International Renewable Energy Agency. Available from: <http://www.irena.org/Publications/rejobs-annual-review-2015.pdf>  
 Same comment for GWEC (2014) which is GWEC (2014) Global wind report. Annual market update. Global Wind Energy Council. Available from: [http://www.gwec.net/GWEC\\_Global\\_Wind\\_2014\\_Report\\_LR](http://www.gwec.net/GWEC_Global_Wind_2014_Report_LR)  
 25 — [www.dowcorning.com/content/news/Silicones\\_Make\\_Wind\\_Energy\\_a\\_Breeze.asp](http://www.dowcorning.com/content/news/Silicones_Make_Wind_Energy_a_Breeze.asp)

# HEALTHCARE

The ten largest global medical device markets comprise nearly three quarters (73%) of the total market of €215 billion. Among European countries, significant markets include Germany and France. The medical device sector is highly innovative: on average, companies spend 12% of their revenue on R&D. The global pharmaceutical industry generated almost €869 billion in 2011 from sales revenue. In Europe, Germany and France are the largest markets, constituting €50 billion and €44 billion respectively.

••• Silicones **reduce patient risk, enable life enhancing medical devices and contribute towards various innovations**, such as pacemakers' cochlear implants and wearable sensors. Their particular characteristics include biocompatibility and biodegradability. They are resistant to bacteria and hence are easily sterilised, 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**.

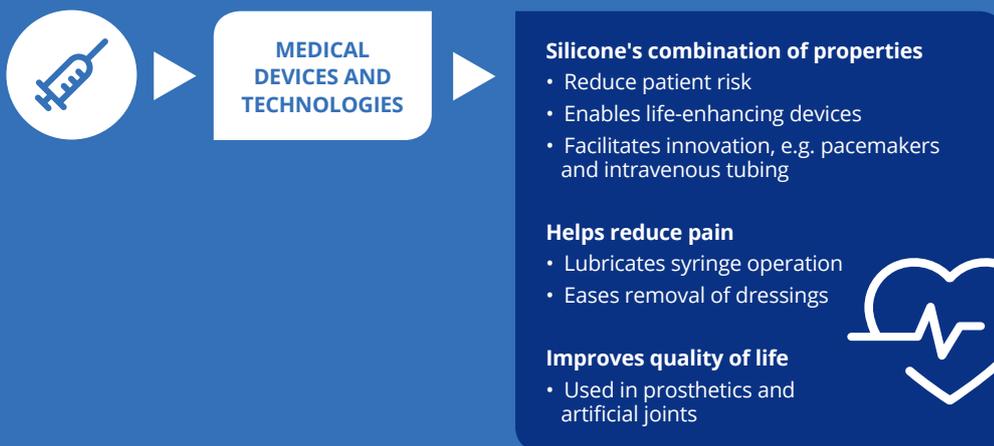
••• It has been found that silicone dressings can reduce pain on removal, reducing anxiety alongside faster healing. According to one study Silicone dressing increased wear time of the dressing by an average of 84%<sup>26</sup>, leading to **cost savings in public health services**.

••• 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<sup>27</sup>.

••• Silicone antifoam additives are an **important suppressant of foam/ gas in stomachs** and are thus used in many antifatulent/ antacid products<sup>28</sup>.

••• Silicones improve spread ability, emolliency and lubrication, resulting in **better usage of medication**.

## Example of the socioeconomic contributions of silicones



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

27 — 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. Europe produces about a quarter of total paper and pulp volumes, with Sweden and Finland being among the largest producers.

.... Silicones are the most widely used **antifoam/ defoaming agents** in the oil and gas industry<sup>29</sup>. They contribute to **maintaining throughput and production** in wells, rigs, refineries and in the transportation of oils. They also **deliver "major savings"**<sup>30</sup>, for instance by preventing oil leakage and downstream equipment damage<sup>31</sup>.

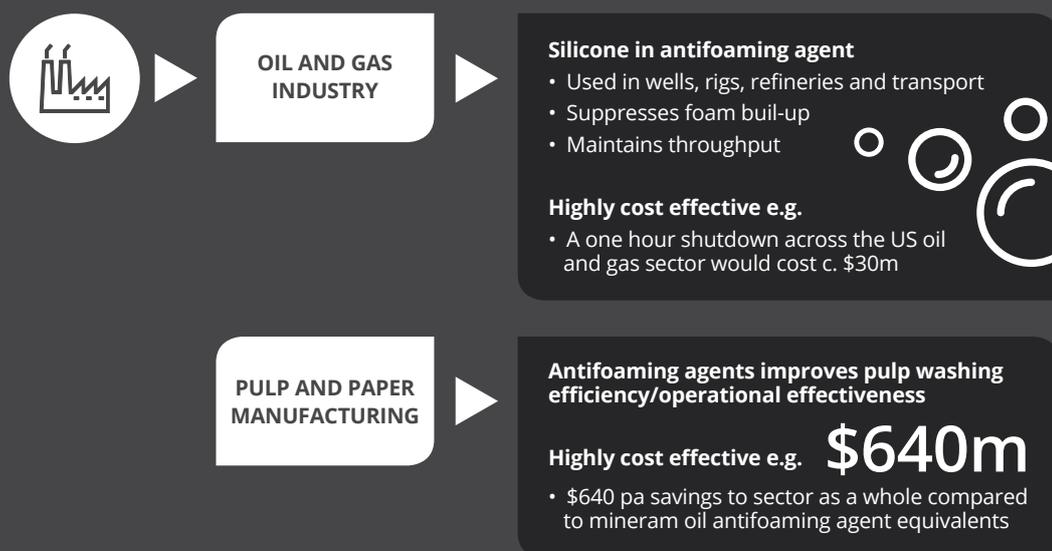
.... Industry consultation has indicated that a loss of silicone products is likely to have further operational implications (and thus higher costs), such as: **loss in efficiency of drilling mud, increased presence of foam/ bubbles in gas/oil separation, storage and oil piping.**

.... 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 antifoamers/ defoamers are typically added at doses significantly below the volumes typically required when using 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 €575 million** compared to a scenario where only mineral oil antifoams are used<sup>32</sup>.

## Example of the socioeconomic contributions of silicones



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

30 — [www.akersolutions.com/Documents/Drilling%20Technologies/Process%20Systems/Processing\\_solution\\_brochure.pdf](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. [www.forestindustries.se/documentation/statistics\\_ppt\\_files/international/global-paper-production-by-region](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** (e.g. skin care, hair care, cosmetics, fragrances, oral care, deodorants, sun care, among others) were €408 billion<sup>33</sup>. The largest market is Europe, where Germany has the largest cosmetics market, valued at €12.9 billion, followed by France (€10.5 billion), Italy (€9.5 billion) and Spain (€6.4 billion) (Cosmetics Europe, 2013). In 2013, the **household care market** size totalled €128 billion<sup>34</sup>.

••• 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)<sup>35</sup>. 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 .

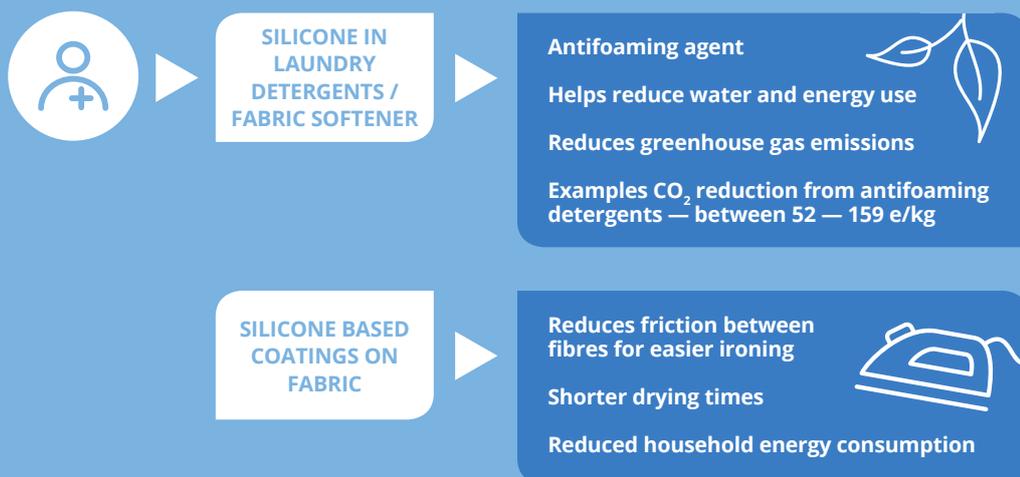
••• In various products, the ‘film-forming’ properties of silicones substantively increase wash-off resistance reducing the number of applications needed and hence providing **savings for the final consumer**.

••• 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<sub>2</sub>e/kg and 159 kg CO<sub>2</sub>e/kg** (Brandt et al., 2012)<sup>37</sup>.

••• 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 tumble dryers<sup>37b</sup> can have energy savings of up to 0.9 TWh equivalent to 0.4 Mt CO<sub>2</sub> p.a.)

••• Silicones improve the efficiency of the active cleaning agent, **reducing the amount of detergent needed and the temperature of the washing cycle**, thus reducing energy use.

## Example of the socioeconomic contributions of silicones



33 — Euromonitor International (2014) Global trends in beauty and personal care: Opportunities for future. [www.slideshare.net/Euromonitor/global-trends-in-beauty-and-personal-care?related=1](http://www.slideshare.net/Euromonitor/global-trends-in-beauty-and-personal-care?related=1)

34 — This figure includes Brazil, China, the UK and U.S.

35 — CES (n.d.) A socioeconomic study on silicones in Europe, [www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study\\_brochure\\_v45.pdf](http://www.silicones.eu/uploads/Modules/Resources/ces-the-socio-economic-study_brochure_v45.pdf)

36 — Based on consultation responses from the GSC survey.

37 — 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.

37b — [www.randd.defra.gov.uk/Document.aspx?Document=EV0419\\_8640\\_OTH.pdf](http://www.randd.defra.gov.uk/Document.aspx?Document=EV0419_8640_OTH.pdf)

# 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 €9 billion as of 2014. The global output for the **textile industry** had an estimated worth of €849 billion in 2012, with a market value of the sector of €2 billion. In 2010, the global **printing market** had a market value of €704 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 release liner market, **silicone release coatings for liners have an estimated market value of €538 million**<sup>39</sup>. Silicone polymers are used for ~70% of release liners and provides various performance characteristics due to their low surface tension and hence low friction (Gordon et al., 1998).

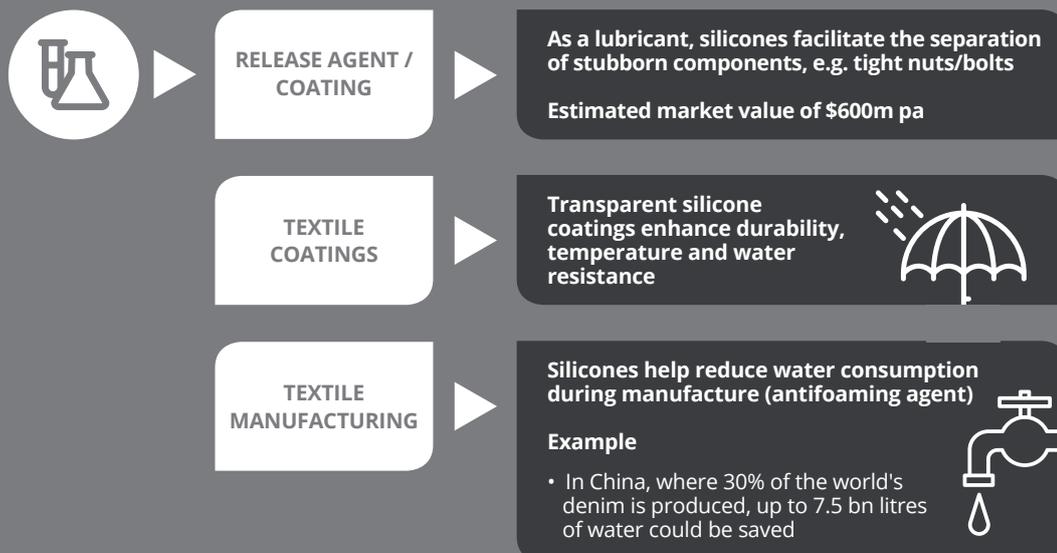
••• In textiles and clothing **transparent silicone coatings contribute to enhanced durability, dirt, temperature and water-resistance**. The durability offered by silicone coatings are particularly beneficial for outdoor clothing<sup>40</sup>.

••• 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**<sup>41</sup>.

••• Silicones also **facilitate high speed printing techniques, increasing production efficiency and reducing costs**.

## Example of the socioeconomic contributions of silicones



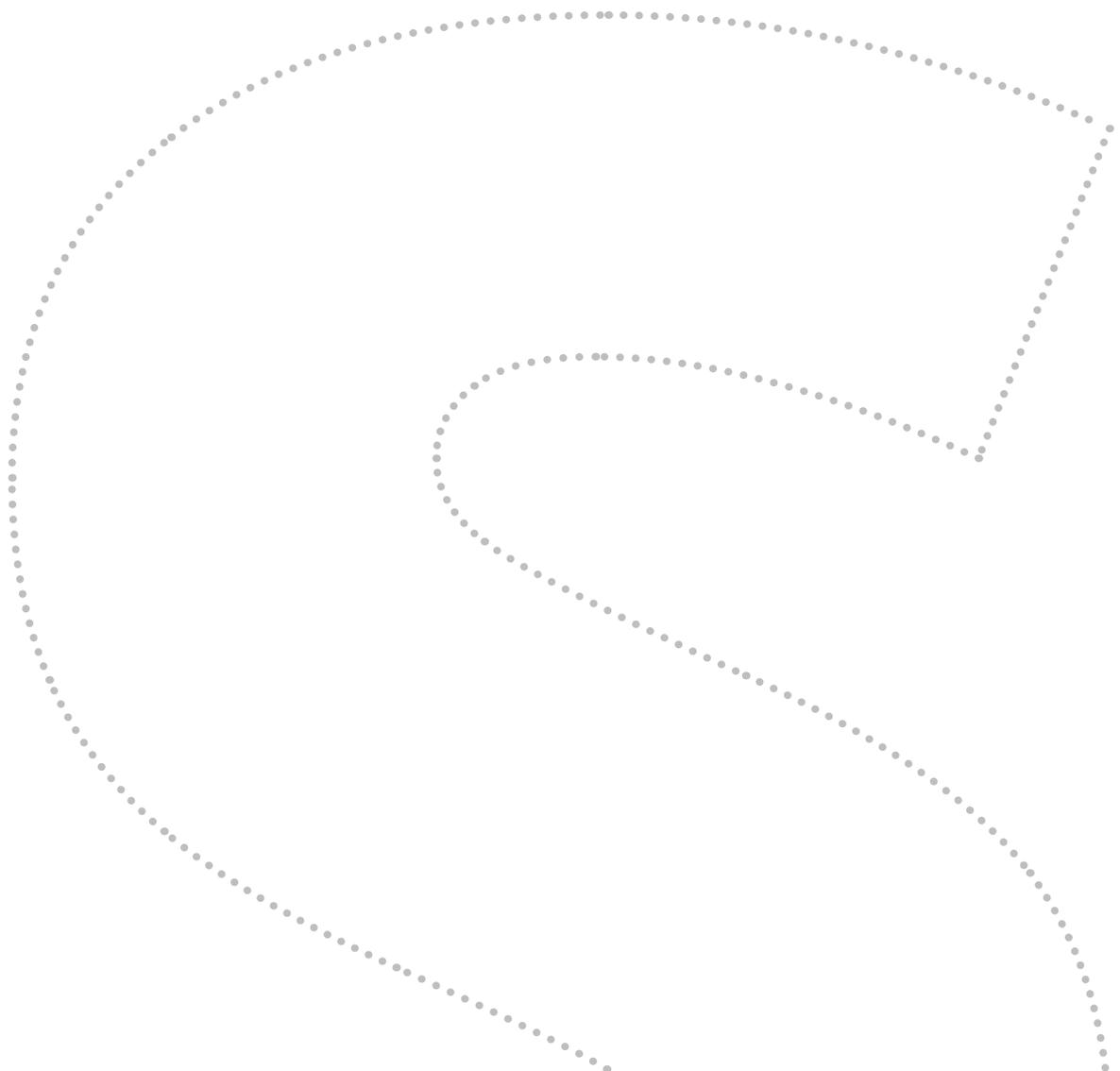
38 — Based on consultation response from the GSC survey

39 — Gordon et al. (1998) Silicone release coatings: A closer look at release mechanisms. Dow Corning Publication. [www.dowcorning.com/content/publishedlit/26-016.pdf](http://www.dowcorning.com/content/publishedlit/26-016.pdf)

40 — Based on consultation responses to the GSC survey.

41 — Barnhart, S. (2000) Agricultural Spray Adjuvant Technology – Sorting out the adjuvant puzzle (presentation).







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