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SILICON-CHEMISTRY CARBON BALANCE

AN ASSESSMENT OF GREENHOUSE GAS EMISSIONS AND REDUCTIONS

Covering the Production, Use and End-of-Life of Silicones, Siloxanes and Silane Products in Europe, North America and Japan

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Commissioned by
Global Silicones Council
Centre Européen des Silicones
Silicones Environmental, Health and Safety Council of North America
Silicone Industry Association of Japan

1 PURPOSE OF THE STUDY

This study aims to provide consumers, manufacturers, retailers and policymakers with reliable data to implement effective sustainability and energy efficiency measures and decisions. It is a first, important step toward a better assessment of silicon-based chemistry products.

Commissioned by the Global Silicones Council, this study looks at the greenhouse-gas emissions linked to the entire life cycle of silicone, siloxane and silane products in Europe, North America and Japan. The first of its kind, this study takes a cradle-to-grave perspective, embracing the production, use and waste phases.

We've measured the GHG emissions linked to the total market for silicones, siloxanes and silane products in the three regions. The emissions are then compared with GHG abatement effects, or emission reductions, resulting from the use of the products in different applications.

The Global Silicones Council is an umbrella organization coordinating activities of the silicone industry associations in Europe, North America and Japan.

2 FINDINGS

1 | Using silicones, siloxanes and silane products generates greenhouse-gas emission reductions that outweigh the impacts of production and end-of-life disposal by a factor of 9. In other words, for every ton of CO_2 emitted, the use of silicones allows for savings 9 times greater. This is at the top of the range of previous estimates made for chemistry applications across the board. (cf. ICCA, 2009.)

2 | The use of silicon-chemistry products in Europe, North America and Japan yields GHG emission reductions equivalent to about 54 million tons of CO_2. This is equivalent to the emissions required to heat 10 million homes in the area covered by the study – or three times the number of households in Greater London.

3 | The use of silicone products allows for greater efficiency in energy and raw materials consumption in many essential products and services – and thus reduces their carbon footprint.

4 | A relatively modest quantity of silicone, siloxane or silane can be sufficient to obtain a large increase in the efficiency of processes, energy consumption and use of materials. Examples include antifoaming agents, paint additives, glass fibre coating for composite materials and silanes used to reduce the rolling resistance of tyres.

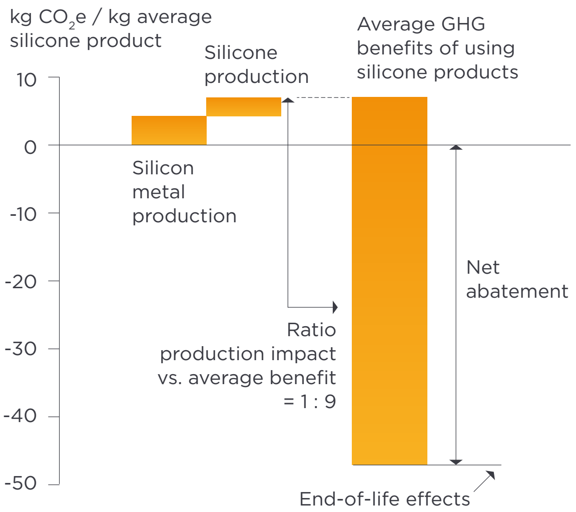
5 | Silicones, siloxanes and silane products used in automotive, construction, and solar-energy applications currently provide the largest contributions to net reductions in GHG emissions.

6 | **There is a potential for significant increase of sustainability benefits:**

A | Silicones are powerful technology enablers. Some existing and emerging silicon-chemistry applications – such as chlorosilanes used to make solar grade silicon in the photovoltaic industry, siloxane additives for high performance thermal insulation and silicone-based marine antifouling coatings – have potentially huge beneficial effects on worldwide GHG emissions.

B | Increased use of silicones in common applications such as masonry water repellents, glass fibre coating and tyres would considerably contribute to additional GHG emission reductions worldwide.

C | Reducing the share of fossil fuels in the power used to produce silicon metal (the raw material for silicones, siloxanes and silanes) would substantially cut the carbon footprint of silicone production.



3 SCOPE AND METHODOLOGY

The study generally follows the methodological guidelines for life-cycle assessment under ISO 14040/44. Overall market conclusions are based on highly conservative extrapolations in order to avoid overestimating any benefits.

Professor Adisa Azapagic at the University of Manchester in the UK has carried out an independent critical review of the study.
The relevant market (including silanes used to make photovoltaic-power cells) is estimated at 1.14 million metric tons per year, of which:

- **690,000 tons in Europe**
- **331,000 tons in North America**
- **121,000 tons in Japan**

The market is split into differentiated product groups with specific applications.

The GHG calculations break down as follows:

- GHG emissions related to production and end-of-life for all applications, i.e. 100% of the market;
- GHG abatement benefits calculated for clearly identifiable applications where the use of silicone, siloxane and silane products has an influence on GHG emissions; These applications are covered by 26 case studies, which account for 59% of the market;
- For applications that could not be clearly identified or quantified, the average GHG abatement found in the case studies was extrapolated to a further 10% of the market. We assumed no GHG abatement from the use of silicon-chemistry products in the remaining 31%.

In the 26 case studies, GHG abatement benefits are calculated based on a comparison with alternative materials or alternative (sometimes historical) ways to provide a similar use in each application.

The GHG **net benefit** of each case study and of the total market is calculated by sub-tracting the GHG impacts of production and end-of-life from the abatement benefits during usage.
The **benefit/impact ratio** is calculated by dividing the benefits by the impacts from production and end-of-life.

A figure smaller than 1 means that the impacts of production and waste management are greater than the benefits, indicating that the silicone product is less advantageous than the alternative; a figure greater than 1 indicates that the use of the silicone product is advantageous in terms of GHG emissions.

[1] Silicon chemistry covers polymeric siloxanes, which are commonly known as silicones; cyclic and low molecular weight polydimethylsiloxanes; and silanes, which are reactive, silicon-containing chemical intermediates and additives.

The table below provides an overview of the results of the different case studies and the extrapolation to the overall market:

No.	Name of Case Study	Market Europe, North America, Japan	Benefit/ impact ratio	Absolute GHG net-benefits
		Tons per year		1,000 t CO_2 equivalent
1	Sealants Kitchen/Bathroom	79.400	1,1	-54
2	Sealants Windows IG unit	56.700	27,7	-12.226
3	Sealants Expansion Joints	38.900	0,9	16
4	High Quality Sealants & Adhesives	10.100	11,7	-925
5	Masonry Water Repellent - concrete	2.500	25,3	-378
6	Masonry Water Repellent - bricks	10.100	13,2	-650
7	PU Additives for Thermal Insulation in Construction	9.300	2,7	-80
8	PU Additives for Thermal Insulation in Appliances	4.700	17,0	-371
9	Cooling Liquid in Transformers	8.700	1,6	-28
10	Electrical Isolators	9.600	2,4	-128
11	Chlorosilane for Solar Grade Silicon	360.100	7,5	-9.228
12	Anti-foaming in Paper Production	10.200	27,1	-2.488
13	Paint Additives	1.900	6,8	-5
14	Silanes for Glass Fiber Coating	1.900	27,1	-167
15	Heat-Resistant Industrial Coatings	3.200	7,3	-112
16	Adhesion Promoter for Coatings	1.900	170,1	-731
17	Antifoaming in Detergents	7.800	12,7	-778
18	Baby Teats	1.900	0,3	8
19	Heat Resistant Coating of Personal Appliances	1.600	13,8	-142
20	Bakeware	1.900	1,2	-3
21	Rubber in Motor Construction	33.800	86,3	-19.162
22	Green Tyres	6.400	66,5	-2.325
23	Coating for Polycarbonate	1.800	2,9	-26
24	Coating for Car Exhausts	500	9,2	-25
25	Marine Coatings	100	182,2	-126
26	Automotive Bonding	5.900	28,4	-1.076
	Sum of case studies	**670.900**	**13,7**	**-51.208**
	GHG benefits not cov. by case studies	114.000	8,7	-5.530
	Applications without GHG benefits	357.000	0,0	2.500
	Total market / weighted average	**1.141.900**	**8,9**	**-54.240**