

# Sustainability report 2016



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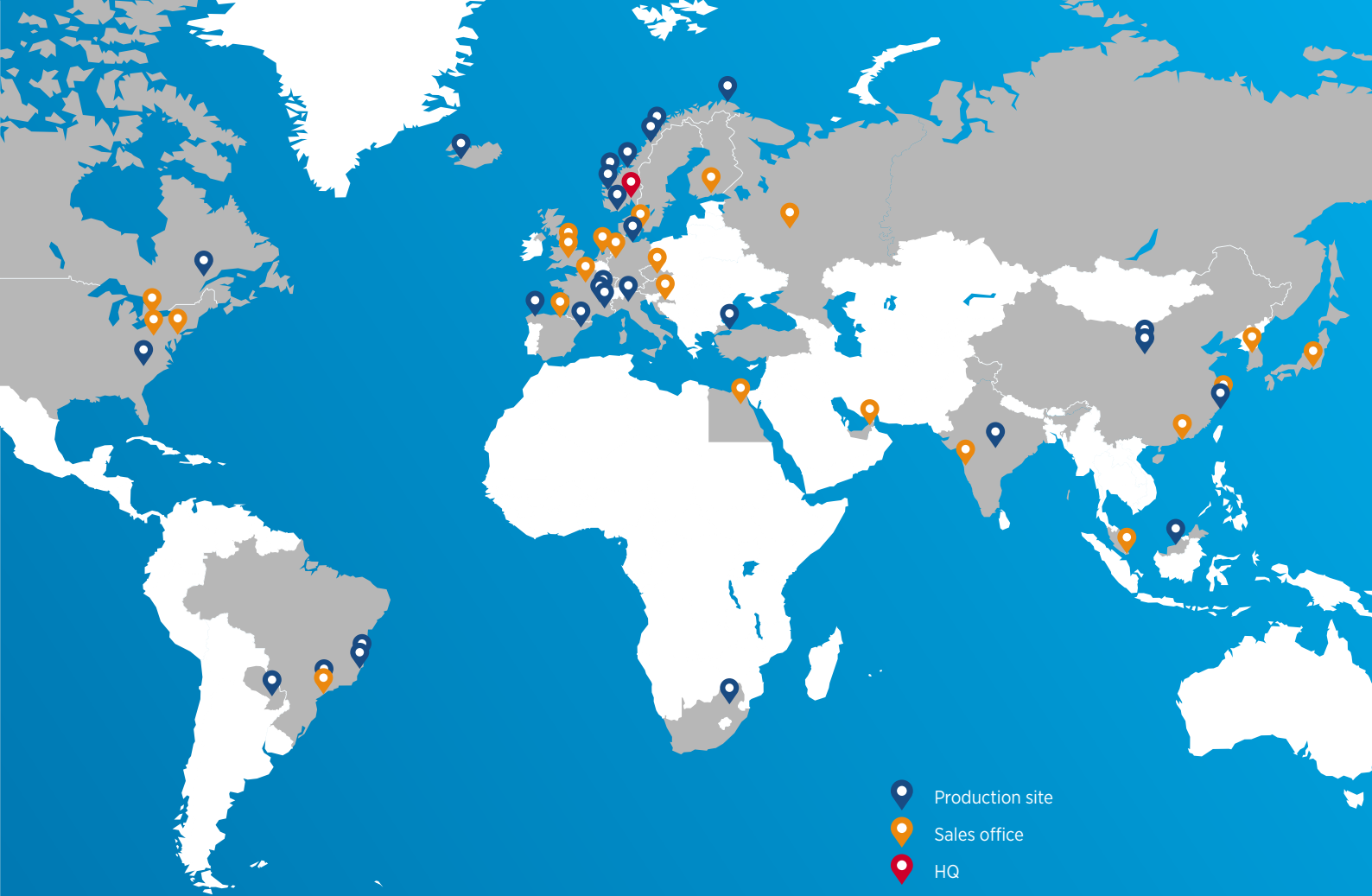
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## Elkem – an overview

Elkem is one of the world's leading companies in the environmentally responsible manufacture of metals and materials. The main activities are related to production and sale of silicon materials, silicones, ferrosilicon, specialty alloys for the foundry industry, carbon products and microsilica. In 2016 the turnover was NOK 14,226 million and the net profit NOK 758 million. Elkem has 3,800 employees in over 40 countries throughout the world. Elkem is owned by China National Bluestar.



## Key figures

<b>FINANCIALS</b>	<b>UNIT</b>	<b>2016</b>	<b>2015</b>	<b>2014*</b>	<b>2013*</b>
Revenues	NOK million	14 226	14 541	12 694	11 473
EBITDA	NOK million	1 618	2 207	1 248	819
EBIT	NOK million	941	1 310	527	345
Profit for the year	NOK million	758	842	161	(268)
Total assets	NOK million	14 813	14 477	14 579	13 086
Net interest-bearing assets /(liabilities)	NOK million	(1 729)	(1 928)	(3 530)	(3 538)
Equity	NOK million	7 459	6 167	4 754	4 022
Equity ratio	Per cent	50.4	42.6	32.6	30.7
ROCE	Per cent	10.2	15.1	6.7	4.8
No. of fulltime equivalent employees	Numbers	3 806	3 628	3,459	3 420
<b>HEALTH AND SAFETY</b>					
Sick leave rate	Per cent	3.8	3.7	3.4	3.7
No. of lost time injuries per million work hours	H1	2.4	1.3	2.1	0.8
<b>ENERGY AND EMISSIONS**</b>					
Energy recovered	GWh	644	483	421	450
CO <sub>2</sub> emissions	1000 tonnes	1841	1790	1771	1588
NO <sub>x</sub> emissions	Tonnes	7427	8353	8969	7755
SO <sub>2</sub> emissions	Tonnes	7882	7417	7842	7929

\* Bluestar Silicones was acquired in 2015 and is included in comparable figures. Elkem Solar was divested in 2015 and is excluded in comparable figures. Please refer to accounting principles in consolidated financial statement for Elkem AS group for more details.

\*\* The emissions from 2013 to 2016 include the numbers from Elkem Rana, acquired in 2016, and will therefor differ from the figures presented in last year's report.

## Incremental and step changes are necessary to improve sustainability

Elkem works continuously to reduce the company's environmental footprint, both in our day-to-day improvement work and our long-term R&D programmes. We do this because we want to stay at the front as a profitable and responsible producer of advanced materials.

Elkem's sustainability philosophy is based on the general principle of producing as efficiently as possible and with the maximum use of all side streams, like materials and energy.

### **EBS and sustainability go hand in hand**

The essence of Elkem's culture is the Elkem Business System (EBS). In EBS we focus on working in a lean and safe manner, to eliminate all kinds of waste and to always look for potential to further improve our performance. I see a clear link between EBS and the concept of sustainability, as our key sustainability initiatives are related to optimising our use of resources and protecting people, environment and property from harm.



In 2016 we continued our dedicated work to implement major projects aimed at reducing our emissions of Chemical oxygen demand (COD) to water, sulphur, NO<sub>x</sub> and dust. This gives results. To give an example, our COD emissions in 2016 have decreased 14% compared to 2015. We are reducing our energy consumption and increasing the energy recovery from our production. Our research and development teams in all divisions are dedicated to developing new products and new processes.

### **Our long-term goal: Carbon neutral metal production**

Elkem's main emissions of CO<sub>2</sub> stem from the silicon and ferrosilicon plants. In 2016 we continued our research programme into carbon neutral metal production (CNMP). The initial part of the programme showed that by using biocarbon instead of carbon in the production processes, Elkem could become carbon neutral. It also showed that by recovering the heat from both the biocarbon and the silicon production, we could in fact become electricity neutral as well. However, our research also demonstrated that the economic margins are challenging, and closely dependant on the performance of the pyrolysis technology. Therefore we have initiated a new R&D project called PyrOPT. The goal of this project is to optimise the pyrolysis process to get charcoal of a quality that fits our needs. At the same time we wish to maximize the value of the side streams of gas and condensate, e.g. by making profitable and useful products like biofuels and green binders.

We have also initiated a research project where we are looking into whether it is possible to close the top of the furnace, leading to a controlled production of CO inside the furnace, rather than CO<sub>2</sub>-emissions. CO gas is a valuable product that can be used either for industrial or energy purposes. If both R&D projects are successful, our silicon and ferrosilicon production might become CO<sub>2</sub>-neutral. The projects will also have other important positive effects like reducing NO<sub>x</sub> emissions by 90%.

Elkem's history has always been characterized by our future-oriented and ambitious approach to innovation. As the readers of this report will see, today, the majority of our R&D projects are focused on finding solutions that at the same time strengthen our business and contribute to improved results for the environment, safety and health.

A handwritten signature in blue ink that reads "Helge Aasen". The signature is fluid and cursive.

Helge Aasen  
CEO Elkem AS



# People are the driving force

Elkem Business System (EBS) forms the foundation of Elkem's corporate culture and operations. EBS is a set of fundamental principles describing how employees at all levels and in all positions shall work together to achieve common goals and continuous improvement.

## Individual responsibility

One of the main EBS principles is that people are the driving force. This means that each Elkem employee is encouraged and expected to actively look for and suggest improvements to the processes he or she is involved in. In order to ensure that everyone can take part in and contribute to the continuous improvement work, targeted training sessions are arranged at operator, team leader, administration and management levels. All Elkem's plants have established arenas for active daily improvement work. A deep level of personal engagement from all employees is an important success factor for Elkem. Annual development discussions provide basis for the professional and personal development of Elkem's employees.

## Leadership responsibility

Another key principle of EBS is that leaders are coaches and must have in-depth knowledge about critical processes. Elkem's leaders are expected to be regularly present at the production facilities to see for themselves what is happening, engage in discussions with employees about their tasks, the production flow and improvement ideas. In addition to good coaching and listening skills, the ability to give direct, specific feedback on how each employee is performing his or her duties is an important leadership skill in Elkem.

## The four main principles of Elkem Business System are:

### 1. Make to use

The customer's needs are always in focus. This applies also internally in Elkem, where everyone in the organisation is interlinked as suppliers and customers in a value chain.

### 2. Empowered people

Elkem ascribes 70% of its success to human input and 30% to the underlying system and technical equipment. People who perform the tasks are the experts, and together they constitute Elkem's resource base.

### 3. Eliminating waste

Eliminating all forms of waste, including waste of time and human resources, lies at the heart of Elkem's goal of continuous improvement.

### 4. Processes in control

All processes shall be stable and predictable, and variations shall be avoided.



Helge Aasen with the winners

## Continuous improvements in Elkem Carbon Brazil

Flavio Piantavinha (to the left) was the winner of 2016 Elkem Carbon Brazil Continuous Improvement Programme with the project Business Intelligence of Invoiced amounts. The annual award is part of a programme in Elkem Brazil that recognises good ideas and suggestions.

Another price winner, Rodrigo Vasconcelos (to the right), is the team leader for the Critical Processes Management work with Naphthalene production. Through systematic work based on tools from EBS, his team has improved the productivity, quality and safety related to process and, at the same time, eliminated the need for investment to increase capacity.

While visiting Elkem Carbon units in Brazil CEO Helge Aasen and Senior Vice President Asbjørn Søvik complimented both the winners and the team at Elkem Carbon Brazil with excellent EBS work and results in the areas of 5S, dust reduction, flow improvements and on-going implementation of Critical Processes Management.

## Sustainability is the backbone of business

Sustainability has become the backbone of any chemical or metallurgical company, and is today a prerequisite for a successful global company. From a day-to-day business perspective, it might not seem necessary to bother with sustainability issues. However, to stay in business long term companies have to focus on sustainability and deliver results. There are many examples of how businesses get into trouble and loose out because management lacks understanding of the importance of sustainable business practices.

In my mind, there are two main pillars to sustainability. Health, safety and compliance is prerequisites to sustainability and no business can be called sustainable unless health, safety and compliance is a priority on the management and board agendas. Furthermore, energy efficiency and environmental protection is at the core of sustainability.

### **EHS and compliance**

Elkem has a very good safety performance overall and management awareness is high. However, the 2016 EHS-numbers are not as good as in 2015 and we strongly regret a fatality in France with one of our contractors. According to our procedures, measures are being taken to learn from such tragic accidents to prevent them from happening again.

When it comes to compliance to rules and regulations, I regard Elkem as true landmark and an outstanding example in the industry.

### **Energy and environment**

Elkem has high ambitions and shows good results on energy preservation and environmental protection. Innovation plays a key role, both regarding the development of better and more sustainable products and improved processes.

The global societal trends linked to sustainability are growing worldwide. Expectations of sustainability have lately become more tangible in Asia and specifically in China, where the government is pushing the importance of sustainability more and more. The sustainability trends shape expectations from governments, customers and our employees. We must deliver on sustainability to maintain our license to operate, to keep our customers satisfied and be an attractive employer.

Sustainability trends also affect the market. For Elkem, major trends like energy saving, increased use of renewable energy and electric mobility translates into business opportunities. One example: Silicon based rechargeable batteries are expected to have at least twice the capacity of today's batteries. Better batteries are a prerequisite for the transition to fossil free transportation and better use of renewable energy sources.

Elkem's silicones division, Elkem Silicones, has a high product innovation pace and has launched a number of new products that improve the safety, health and everyday life for people all over the world. An example is the development of silicone gels for scar care and wound management that reduce pain for the patient as well as reducing the consumption of wound dressing material in health care institutions.

These examples show how Elkem's materials are both produced in an environmentally responsible way, and improve energy efficiency and reduce waste for the customer, promoting sustainability throughout the value chain.

  
Michael Koenig  
Chairman of the board





## Global employer

**Elkem is a company with vast geographical, cultural and functional diversity within the organisation. The company actively uses the Elkem Business System (EBS) to provide employees with a common approach to both everyday tasks and big decisions.**

To have success Elkem needs competent, empowered and motivated people at all levels. In Elkem, the role of Human Resources (HR) is to support value creation and to strengthen the competitiveness of the company.

In 2016 Elkem acquired Fesil Rana Metall AS in Norway and the iron foundry business of Minex Metallurgical Co. Ltd. in India. At year-end 2016, Elkem employed 3,806 people.

Around half of Elkem's employees work as operators at Elkem's production plants in Brazil, Canada, China, France, Germany, Iceland, India, Italy, Malaysia, Norway, South Africa, Spain, UK and USA. Elkem also operates quartz mines in Spain and Norway. Elkem has sales offices in more than 30 countries, and about 10% of Elkem's staff (400 employees) are engaged in research and development.

### Cooperation

Good cooperation and teamwork between employees and leaders is a prerequisite if Elkem is to cope with what are at times demanding market conditions. Elkem has a long tradition of constructive and mutually beneficial cooperation between employees, their unions and management. Elkem complies with local statutory requirements regarding freedom of association in all countries where we are present. Pursuant to the provisions of the Norwegian Companies Act, employees have two representatives and two observers on the board of Elkem AS.

### Equal opportunities

The process industry is generally male dominated. Women are, however, increasingly expressing an interest in working in our industry, much because of increased automation, less heavy manual work and Elkem's commitment to sustainability in all operations. The percentage of female

employees in Elkem has nevertheless been stable and low at 22%. Among leaders in Elkem, the female share is 26%. The female share among employees in the white-collar population is 35% and for blue-collar only 6%. Elkem values diversity and aims to achieve a better gender balance, looking continuously for ways to improve.

Elkem has production sites and sales offices on four continents. EBS is the common denominator and the base of Elkem's company culture and values that tie this diverse organisation together. In EBS, the employees are considered specialists in their fields and thus shall be involved in decisions affecting them as well as in continuous improvements in their respective work areas. All employees in Elkem shall be listened to and treated with respect. Discrimination in any form is strictly forbidden in Elkem. Discrimination is not only unethical; it is also totally incompatible with our basic workplace philosophy.

# Injuries at work are not acceptable

Elkem's health and safety work is based on a zero harm philosophy. We do not accept that injuries or illnesses are unavoidable facts of life in our industry. Unfortunately, the year 2016 was a setback compared to 2015, when Elkem had record results.



Elkem has been on a downward trend in the numbers of injuries for many years, reducing the likelihood of injuries with almost 90% since the turn of the century. From 2011 the improvement stagnated until 2015, when results improved more than two-fold, giving Elkem the best safety results ever. Unfortunately, the number of injuries at some of the plants escalated in 2016, bringing the total results back to the level seen before 2015. However, the majority of plants were still showing very good results.

In 2016 the total recordable injury rate increased from 1.8 (2015) to 5.3 injuries per million working hours. This includes both injuries with lost working days (H1) and other injuries that required medical treatment and/or restricted work (H2).

The total numbers of recordable injuries rose from 17 in 2015 to 34 in 2016. This includes numbers from the Silicones division that was merged with Elkem in June 2015, increasing the total workforce with approximately 1,500 employees. This means that a higher absolute number of injuries could be expected, even though recordable rates should not have increased, as they are calculated per million working hours. Previously, some of the Silicones division's plants did have high injury rates and this explains some of the increase. The Elkem health and

safety programme 'FOKUS' is now being implemented at all plants in the Silicones division.

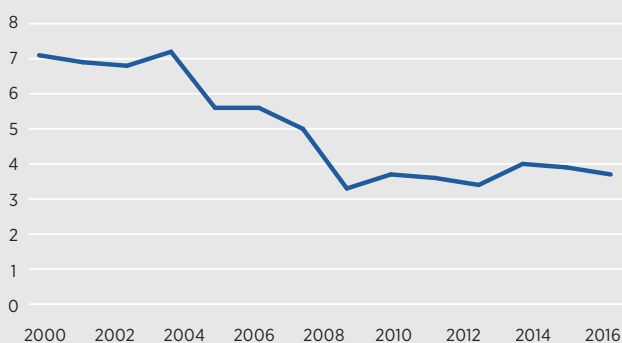
## Contractor safety

Contractors deliver services of many kinds at Elkem's plants, and are often an integrated part of the plants' daily operations. Contractors had a total recordable injury rate of 18 in 2016, more than three times as high as for Elkem's employees. Part of the difference between recordable rates for Elkem's employees and contractors can be explained by a substantially lower number of working hours for contractors and the fact that most contractors do manual physical maintenance and project work, compared to own employees who are more involved in routine operations and administrative functions. Elkem will continue to focus on the safety of our contractors. Contractor employees working on Elkem's property are subject to the same EHS requirements as Elkem's own employees, and receive training and follow-up to ensure that they have a safe and healthy working environment.

## Fatal injuries

It is with regret we have to report that a contractor at one of the Silicones division's plants in France had a fatal accident in 2016. The contractor was working with

Sick leave in %



Trend in number of injuries





a forklift inside a warehouse for storing flammable chemicals. After damaging one of the drums with a forklift, finished product leaked out and caught fire. French police is still investigating the incident.

The fact that simple everyday tasks can result in fatalities shows how important it is to focus on the details and fully understand hazards associated with jobs before they are executed. The incident has been thoroughly analysed by Elkem, and learning points are used to improve operational safety at all plants.

### Training and sharing

- Full understanding of health and safety risks and challenges have high priority at all plants. This understanding is obtained through extensive training, comprehensive risk assessment and through the sharing of information and experiences between plants. Key activities include basic training for all employees with training materials available in a number of languages.
- An electronic document library is open

for all EHS employees in the Elkem group and all employees have read access to the information.

- An annual EHS conference is held for 60-70 key EHS personnel from all plants and divisions sharing and discussing EHS improvements, incidents, practices and policies.
- Special EHS sessions are held for young leaders.

### Personal responsibility

Our statistics clearly show that it is possible to run difficult and potentially dangerous operations with a large work force without injuries. Several of our plants have achieved this for a number of years in succession. To achieve this type of result we must know and understand what may cause harm in the working environment and how we can implement measures to avoid harm. This means looking closely at all unsafe conditions and unsafe actions to understand why they exist and how we can correct them. Our statistics also show that the vast majority of all injuries are caused by unsafe actions; individual behavior where

employees are not taking the time and effort to understand and prevent possible hazards, do not follow prescribed safe working procedures and/or are not using correct protective equipment.

All of Elkem's employees have a personal responsibility to participate actively in risk reduction activities and to perform their daily work in a safe and healthy manner.

### Top management follow-up

The status of Elkem's safety work is discussed every week at division and group management levels. Incident, injury and deviation reporting, investigation and mitigation is a major part of Elkem's improvement work. All divisions provide EHS status reports every month. Whenever serious injuries and/or high-risk incidents happen, detailed presentations of the course of events, causes and lessons learned are prepared and distributed. This enables the learning points to be shared between plants and divisions, and contributes to similar incidents being avoided in the future.

## Injuries can be avoided

Elkem's plant in Shanghai is one of the larger silicones plants with about 200 employees. They have operated without any recordable injuries since 2010. Erimisa operates quartz mines with a total of 70 employees in 5 different locations in Spain. Their last recordable injury was in 2012. Carboderivados in Brazil's 50 employees have processed potentially harmful chemicals for many years and have not had recordable injuries since 2012. These are just a few examples of different production units that show that operations can be run long-term without harm.

### Safety champions

Plant	Last H1/H2	Years since
Shanghai (BSI)	01/04/2010	6.9
Carboderivados	05/06/2012	4.7
Erimisa	18/06/2012	4.7
R&D Saint-Fons	13/10/2014	2.3
Tana	15/10/2014	2.3

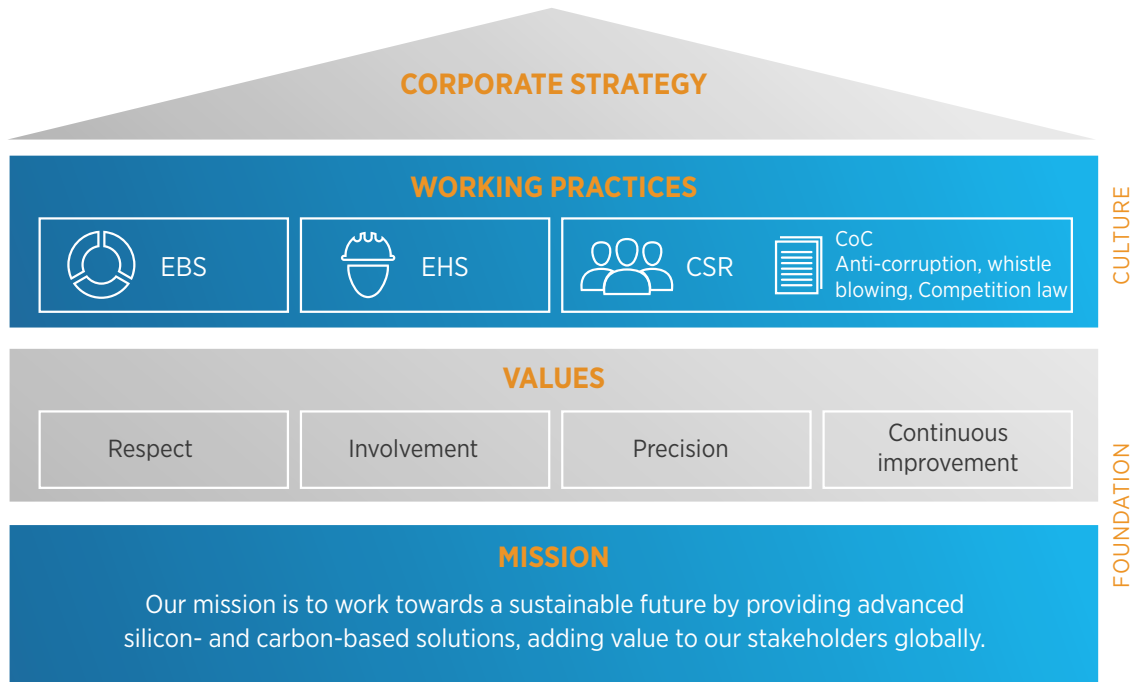
## FOKUS

FOKUS is Elkem's programme for environment, health and safety in the workplace. FOKUS is closely linked to Elkem Business System (EBS) with an emphasis on continuous improvement and each employee's involvement and responsibility to contribute to good results. FOKUS has five fundamental principles:

1. Improvement has no limits.
2. Zero harm philosophy: All incidents and injuries can be prevented.
3. Incidents and/or injuries will always have one or more causes. Causes will always be associated with unsafe conditions, unsafe actions, or a combination of both. Reporting and investigating all incidents and injuries allows us to identify root causes and eliminate them before they cause more serious harm.
4. Effective prevention of harm requires hazard identification, risk analysis and the implementation of actions to reduce unacceptable risk to an acceptable level.
5. Success depends on all employees being actively involved in the health and safety work and sharing the responsibility for a safe working environment.

# Corporate social responsibility in Elkem

Elkem is a signatory to UN Global Compact, and Elkem’s definition of corporate social responsibility (CSR) is based on the ten UN Global Compact principles. CSR forms an important part of Elkem’s business culture.



## Organisation and responsibilities

Elkem’s CEO is the formal owner of Elkem’s policy and programme for corporate social responsibility, and governing documents are subject to board approval. All employees have responsibilities to follow Elkem’s policies and principles, to report discrepancies to his or her immediate supervisor, or Elkem’s function for whistle blowing, and help investigate and correct discrepancies.

Each location and function is responsible for establishing an understanding of how Elkem’s CSR policy affects their specific working environment and develop necessary procedures and routines to ensure full compliance.

The formal CSR framework in Elkem includes the following policies and documents:

- General policy of Elkem AS
- Elkem policy for corporate social responsibility
- Mandate for the CSR steering committee

- Code of conduct
- Whistle blowing
- Anti-corruption policy
- Competition law compliance policy
- Annual sustainability report

## CSR steering committee

The CSR steering committee has the overall responsibility for defining and following up governing documents for corporate social responsibility. The committee has responsibility for Elkem’s annual sustainability reporting.

On a day-to-day basis, support for Elkem’s CSR activities is given by corporate and divisional functions. This includes:

## Corporate help chain functions (HR, EHS, EBS, Legal department)

- Support for competence building and change management within the areas of ethics and social responsibility
- Auditing of own business, suppliers, customers and partners

## Corporate and divisional procurement functions

- Mapping and basic monitoring of suppliers in relation to Elkem’s requirements
- Collaboration with suppliers to improve identified discrepancies
- Termination of relationships with suppliers when the improvement rate is not satisfactory

## Corporate and divisional sales functions

- Mapping and basic monitoring of the business functions (sales office, distributor, agent and customer)
- Collaboration with agents, distributors and customers to improve identified discrepancies
- Termination of relationships with agents, distributors and customers when the improvement rate is not satisfactory

## Training and education

All employees receive a copy of Elkem’s code of Conduct which they are required to discuss with their superior and sign



to confirm their understanding and acceptance of the content. Special training related to social responsibility and focused on understanding how local culture and customs can influence the perception of what is acceptable in different situations, is given to selected employees who will meet this type of challenge in their work.

Selected target group employees are also required to have documented training in Elkem's anti-corruption and competition law compliance policy. Each location is responsible for its own implementation and documentation of training, with support from the corporate HR and legal department. Agents doing business with Elkem's products also have anti-corruption training.

Employees who conduct supplier audits receive additional training in recognised international standards and the use of audit tools. The corporate EHS/CSR function is closely involved in this type of training.

## UN Global Compact 10 principles



**WE SUPPORT**

### 1 Human Rights

- Principle 1:** Businesses should support and respect the protection of internationally proclaimed human rights; and
- Principle 2:** make sure that they are not complicit in human rights abuses.

### 2 Labour

- Principle 3:** Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining;
- Principle 4:** the elimination of all forms of forced and compulsory labour;
- Principle 5:** the effective abolition of child labour; and
- Principle 6:** the elimination of discrimination in respect of employment and occupation.

### 3 Environment

- Principle 7:** Businesses should support a precautionary approach to environmental challenges;
- Principle 8:** undertake initiatives to promote greater environmental responsibility; and
- Principle 9:** encourage the development and diffusion of environmentally friendly technologies.

### 4 Anti-corruption

- Principle 10:** Businesses should work against corruption in all its forms, including extortion and bribery.



## Collaboration to achieve improvements

**Cooperation and dialogue with employees, politicians, local communities, regulatory authorities, organisations, researchers and other interested parties form an important part of Elkem's continuous improvement philosophy.**

### Employees

Elkem strives to create a working environment that employees find fulfilling, both on a personal and professional level. We want our employees to be proud to work for Elkem. Employee involvement at all levels of the organisation is an important part of this and fully integrated in the Elkem Business System. This means that employees are involved in systematic continuous improvement activities throughout Elkem. They are also included in dialogue about working conditions, occupational health and safety, as well as Elkem's economic results and strategic choices.

Elkem needs to attract highly qualified and dedicated employees, and wants to

influence young people to choose educations that are relevant to Elkem, typically science subjects. School visits, trade fairs and other forums are used to meet students near our production sites and sales offices at universities around the world.

### Research institutions

Elkem is dedicated to improving its existing business and developing innovative solutions. To achieve this, world-class research is needed, and Elkem works extensively with many research institutions around the world. International research partners include institutions such as the Wuhan University of Science and Technology (China), L'Ecole des Mines d'Alès (France), Fraunhofer

Institute and Technische Universität Bergakademie Freiberg (Germany), Texas A&M University System (USA), Okayama University (Japan), KTH Royal Institute of Technology (Sweden), the University of Central Lancashire (UK) and NTNU (Norway).

### Regulatory and supervisory authorities

Dialogue with regulatory authorities takes place both as direct contact between Elkem and the authorities, and indirectly, through business associations. Elkem's largest presence is in Norway and France, where many of our plants, as well as our corporate headquarters and major research facilities are located. Elkem

wants to contribute to, and influence, the framework conditions for our industry. An important aspect of Elkem's dialogue with public authorities involves informing about the impact policies will have on our plants and facilities. Elkem is an active member of national and European industry organisations such as Euroalliages, Eurometaux, the European chemical industry council (CEFIC) and industry associations in Norway and France. Important topics for the industry's dialogue with public authorities are emissions and other environmental issues, energy policies and EHS.

### R&D funding

Support to implement major capital intensive research and development (R&D) projects is important to promote industrial innovation and growth.

Elkem is actively involved in several major research projects together with research institutes and industry partners in Norway, France and on EU level. The EU is an important partner. For example, Elkem Technology R&D Center in Kristiansand, Norway, will be an industry partner in a EU project called REE4EU. The project will develop, test and industrialise novel methods for recycling of Rare Earth Elements (REE) from waste

and end-of-life magnets and batteries.

In Norway, Enova, the Research Council of Norway, Innovation Norway, Siva, the Norwegian business sector's NO<sub>x</sub> Fund and the Environmental Fund are important partners to promote R&D breakthrough technologies and their implementation in industry.

### Non-governmental organisations (NGOs)

Elkem maintains informal dialogue with numerous environmental organisations and other NGOs in order to share knowledge about various environmental and social issues associated with the operation of Elkem's plants. Elkem also cooperates formally with certain NGOs, drawing on their competence in matters such as sustainable sourcing of raw materials.

### Corporate sustainability initiatives

Elkem is signatory to the UN Global Compact, the world's largest corporate sustainability initiative. Global Compact challenges us to align our strategies and operations with universal principles on human rights, labour, environment and anti-corruption. Elkem's silicones division is a member of Responsible Care, the chemical industry's global initiative

to drive continuous improvement in environment, health, safety and security performance.

### Local communities

Elkem is focused on being a good neighbour everywhere our operations are located. As a long-term partner, we maintain a good dialogue with neighbours and local politicians. Many of Elkem's plants are cornerstone employers and of great importance to local communities in terms of tax incomes, jobs and community development.

Dialogue with local communities is the responsibility of each plant manager and is carried out both formally and on an informal day-to-day basis. Input from local communities is considered valuable information that helps us improve. Important topics for dialogue with local communities are community development projects, job security, safe operations, emissions and other environmental issues, and traffic generated by the plant. Complaints raised by local communities, and traffic incidents related to our operations are registered and managed in accordance with good practices for incident and deviation management.

## Traffic

Elkem manages most of its own logistics activities stretching from raw material transportation to production sites and to finished product transportation to customers. This general principle

allows us to better manage and influence environmental and safety factors throughout the supply chain.

Transportation of raw materials, intermediates, and some finished products in the Silicones division includes a higher level of risk than in the other Elkem divisions, as many of these products are defined as hazardous goods. The division has strict policies for their logistics activities and follows mandated procedures for hazardous goods transportation. We always use the safest modes of transport and also advise our customers about risks linked to transportation and handling of our hazardous goods.

Elkem has introduced a 'safe truck initiative' in parts of Norway, which means that if there is a reason to doubt whether a truck and/or driver satisfy national safety requirements, loading will be refused. If the identified deviation is not remedied, it is regarded as a breach of contract and the service provider may lose his/her contract.





Richard Li, Elkem Silicones Asia Pacific R&D Manager with children on Summer Silicones Class in Elkem Silicones Shanghai R&D Centre.

## Silicones class for kids

Every summer, the Silicones Shanghai R&D Centre welcomes children to chemistry classes.

- Children normally learn chemistry from books, and its applications in our daily life are not included in the teaching. The summer school's experiments are closely linked with daily life. This way the Silicones class awakens the children's curiosity for chemistry, says Richard Li, Elkem Silicones Asia Pacific R&D Manager. The class also covers the theoretical part of silicone chemistry.

Silicone, in many ways a magic material, captures the children's interest. Funny and lively experiments showcase a variety of silicones applications in our daily life. The silicones class also wants the children to discover the possibilities of using different silicones applications to develop practical solutions in environmental protection.

The Silicones class in Shanghai is held every summer vacation.

## Tech On Wheels

In Mumbai, India, the organisation Masoom along with Elkem launched the Tech On Wheels Bus in February 2016. This is a computer education van for night school students.

Masoom is a not-for-profit organisation establishing quality education in night schools. Masoom is based in Mumbai and works with 60 night schools, reaching 15,000 students in Maharashtra.

Night school students in India are unskilled labourers aged 14 to 21, who work during the day to support their family and study at night to complete their education. They mostly live in slums and come from a poor background.

Night school students have to complete their studies in half the time of day school students. However they do not have access to basic facilities like science labs and computer education. Many are also unaware of skilled career options.

The Tech On Wheels Bus provides night school students with access to computers, online resources, and innovative educational programming. The students also get an international outlook, by exchanging ideas and thoughts with students from USA, through video letters and Skype communication.

Masoom is hoping to increase the enrolment of out-of-school students, thus ensuring more young people complete their basic education. The reach of the bus in the first year is expected to be 1,050 students.



# Responsible business conduct

Successful business depends on confidence and a good reputation. Elkem requires our employees and representatives to promote our values towards colleagues, business associates and society at large.

In accordance with established Elkem principles and business values Elkem has a strong commitment to operate in accordance with responsible, ethical and sound business principles, and to comply with applicable laws and regulations.

## Code of conduct

Elkem's code of conduct is based on the principles of honesty and respect, and must be complied with regardless of where our operations are carried out. Elkem's code of conduct has been approved by the board of directors and applies for all employees and representatives.

We encourage an open discussion about responsible conduct and expect all employees to raise any concerns they might have about unethical and/or illegal behaviour. Reporting concerns and complaints can be done confidentially and, if necessary, anonymously.

Violation of Elkem's code of conduct will not be tolerated and may lead to internal disciplinary action, dismissal or, ultimately, to civil legal action or criminal prosecution.

Should an improper practice or irregularity occur within Elkem we will make the necessary corrections and take remedial action, also with the object of preventing recurrence.

## Anti-corruption

Elkem does not permit or tolerate any form of corruption. Corruption prevents economic development, distorts competition and undermines the rule of law, well-functioning national and international markets and democratic processes.

Elkem is present in several countries where corruption is generally acknowledged as an issue of great concern. Elkem's policy on anti-corruption applies group-wide, worldwide. Several countries' anti-corruption regimes imply extraterritorial application and observing local law only is therefore not sufficient. Elkem's anti-corruption manual explains and elaborates on the content and implications of the anti-corruption policy for Elkem's employees, representatives and partners. Each Elkem business unit is responsible for understanding the specific challenges regarding anti-corruption, the anti-corruption regulations applicable to its operations and for adopting adequate anti-corruption guidance and measures.

Elkem personnel considered exposed to corruption risk must complete training in Elkem's anti-corruption policy and manual, which includes real life dilemmas. Absolute compliance with Elkem's anti-corruption policy is required by all Elkem employees at all times. Any failure to comply with applicable anti-corruption regulations will be considered a serious

breach of the employee's obligations towards Elkem and will most likely result in termination of the employment or other applicable sanctions.

## Compliance with competition law

It is Elkem's general policy to compete vigorously and fairly in full compliance with relevant laws and regulations applicable to our business. Compliance is of special importance in the field of competition law, and Elkem has adopted a competition law policy as well as a compliance programme to ensure group-wide compliance on this matter.

Absolute compliance with competition law is expected of all Elkem employees. No employee should ever assume that it is not in Elkem's interest to comply with competition law. Any failure to take proper care to comply with competition law will be considered a serious breach of the employee's obligations towards Elkem.

Elkem has developed a manual that describes conduct that will or might infringe competition law. Elkem personnel considered exposed to competition law issues are required to participate in competition law training facilitated by Elkem. Business unit leaders have the responsibility to take steps to implement Elkem's policy in their respective organisations.

RESPONSIBLE BUSINESS CONDUCT	Results 2016*
<b>Code of conduct</b> - commitment /signatory	87%
<b>Anti-corruption</b> - training and signatories	97%
<b>Compliance with competition law</b> - implementation of training - result signatories	97%

\* Numbers exclude newly acquired Elkem Rana and ERIMSA which are in the process of being converted to Elkem's CSR system.





# Innovation in Elkem

**Future-oriented and ambitious innovation strategies have been the foundation for Elkem's development and success since Sam Eyde established the company in 1904.**

To enrich our global culture of innovation, and to further strengthen market positions across all business segments, the Elkem innovation team was created in 2016. The team consists of marketing, process and Research and Development (R&D) leaders from all divisions.

## R&D – a key asset to develop sustainable innovation

Elkem's development has always been based on world-class in-house expertise within our core competencies. Moreover, since the acquisition of Bluestar Silicones, we now have an integrated silicon value chain research activity. R&D is at the core of our businesses, and Elkem's R&D centres with their near 400 employees, are strategically located across Asia, Europe, Latin America and the USA. Our commitment to R&D upholds our reputation as a leader in our field and we continuously lead the way in pioneering technologies that ask more from metallurgy and

chemistry. During the last few years, innovation in Elkem has been focused on finding sustainable solutions. Elkem University is the main internal arena for technology transfer and dissemination of new knowledge.

Elkem's innovation strategy covers:

- Incremental innovation: The core of Elkem Business System (EBS) is the organisation's continuous work on improvements. Elkem employees are always looking for improvement potentials, and use EBS tools to describe the potential, find solutions and measure results. This means that Elkem achieves progress that keeps the company equipped to stay competitive.
- Step-change innovation: As we continue to evolve, we look for future growth opportunities by monitoring market trends. Working groups consisting of marketing, technology

and R&D resources support front-end innovation and product development.

- Radical improvements: To keep our position as a world-leading materials producer Elkem also seeks radical improvements through research and by exploring or inventing new markets.

## Innovation as part of the corporate strategy

In Elkem we set innovation targets to achieve both our strategic goals and environmental performance. Examples are carbon neutral metal production, research on reuse of process water and projects on energy recovery and energy efficiency.

The four most important areas for step change innovation or radical improvements are:

- New or improved products and services
  - › The new products are increasingly developed for high-end markets





If you and your company have ideas that may be of interest to Elkem, please contact us. We are always interested in discussing new technology, products or business opportunities or even sharing best practices to enhance our innovation performances.

where huge improvements are required to keep entry barriers and competitive advantage

- › We develop new services to support our customers in the launch of their own products, for instance, technical and safety trainings and fine-tuning of the required properties
- Fundamentally new production methods, equipment and processes that achieve improved quality, improved safety and a smaller environmental footprint of our products, like energy efficiency, resource efficiency, or reduced emissions
- Development of new sources of raw materials
- Innovative ways of working in sales, marketing and production
  - › Innovation is a collaborative way to create value. More and more, different functions and entities are involved to optimise a sustainable value creation and propose new types of innovation such as business model-, product system- or customer experience innovation

### Open innovation

*'The world is becoming too fast, too complex, too networked for any company to have all the answers inside'*

– Yochai Benkler, Harvard.

Collaboration is increasingly important for successful innovation. Open innovation means that we share ideas and create value, and open the mind to new possibilities.

Identifying potential partners and developing relationships with customers, suppliers, research institutions, government authorities and financial markets is therefore an integral part of Elkem's innovation strategy. By working alongside partners with complementary skills to our own, we have enhanced the development of new markets, products, processes and services.

Elkem continues to move production towards ever more specialised solutions and products. Ideas for new products often emerge in meetings where our teams cooperate with the customers to understand and develop solutions to their unmet needs. By continuously looking for

ways to improve our products, focusing on quality rather than just cost, we create lasting value for our customers.

### Collaborative project – sustainable innovation

The open innovation approach to R&D is also made possible by multiple collaborative projects supported by European, Norwegian, Chinese and French governments and through industry clusters such as Eyde in Norway and Axelera and Techtera in France. Many of our most successful research-based innovations come from these research programmes and projects. In 2016, Elkem was recognized as a partner in at least six new collaborative projects devoted to new products or technology such as 3D printing, new markets like health care and new processes like industrialized charcoal production. Thanks to these initiatives, we take part in the reinforcement of cooperative networks of universities, research institutes and industry partners that operate with support from the Norwegian Research Council and French Ministry of Research.

# Profitable silicones innovations

A portfolio of more than 1,200 patents and an average of 10 products developed each year, illustrate Elkem Silicone's capacity to innovate. The division is dedicating more than 4% of its turnover to R&D. Products that are less than five years old generate over 20% of sales.

Almost 230 researchers work every day throughout the world to develop environmentally friendly processes and adapt and create new products for new markets. The R&D, sales, marketing and operations departments work closely together to understand and anticipate customer needs, develop solutions and manufacture new products.

Product and process innovations are in line with major global trends such as the need for environmental protection, the development of health and life sciences, increased urbanization, new forms of mobility and global population growth. Elkem Silicones is intent on creating new market sectors such as connected health, new sensors for autonomous electric vehicles, and combining 3D printing and silicone chemistry.

## Major innovations over the past 10 years

### Eco-design

- 2009: Launch of a new silicone resin manufacturing process – the key raw material for the airbag market – a process to limit effluents and reduce energy costs
- 2011: Development of a new range of green catalysts for silicone materials
- 2014: Start-up of the Cleantech programme seeking to reduce effluents and improve water treatment in Elkem Silicone's factories
- 2016: Introduction of an energy-saver to reduce gas consumption for the distillation column in Roussillon, France

Over the last few years, the Silicones division has developed a Silcolease UV range for release coating applications and in particular for the labels market, as an alternative to solvent-based solutions.

### Life sciences: health care, personal care

- 2011: New range of Mirasil D-DML products for the cosmetics market
- 2012: New Silbione HC2 range adhesive gels for medical applications, non-traumatic removal of plasters for wound treatment, etc.
- 2015: Launch of a 3D printing programme for silicones
- 2016: Development of the Silbione M550 silicone elastomer for long-term medical implant applications

Sophie Schneider, R&D Director Elkem Silicones.



### Safety: food, public safety

2015: Launch of BLUESIL FRC 8470, a new generation of silicone elastomers (EVC) for high fire-resistant cable applications

### Urbanization and mobility

2011: New range of Bluesil NOVOLASTIC products, foams to insulate sub-sea pipelines for oil extraction

2016: Launch of Bluesil ESA 6000HT, a silicone gel solution for new generations of power modules: IGBT (Insulated Gate Bipolar Transistors), part of the silicone development programme for electronic applications

2017: Elkem Silicones will launch a new product for airbag fabric coating

### Global population growth

2011: Launch of the Silcolease OPTIMA range for the release coating market

2012: As leader on the paper release market, the Silicones division is developing the new Silcolease Emulsion 925. In 2017, the Silicones division plans to bring new innovative solutions to this market

2014: Launch of Bluesil RT Foam 3243, a new silicone foam technology for a wide range of sealing applications (e.g. household appliances)

2014: Silcolapse 801 bolsters the range of anti-foams with improved performance, reducing the use of foam in manufacturing processes for paper pulp and offering high machine productivity

### Silicone rubbers save lives

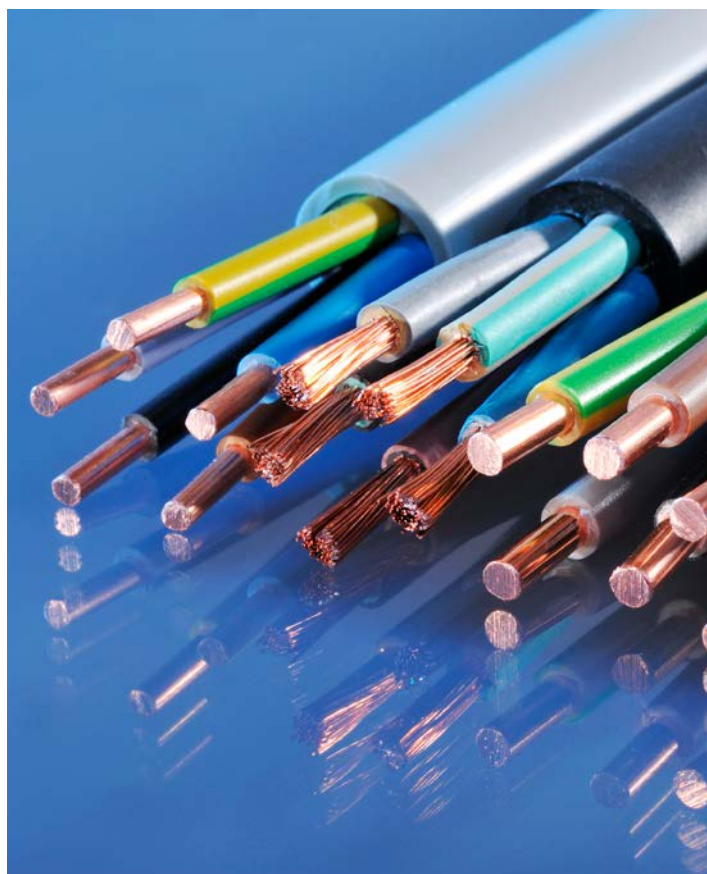
Most deaths in fire incidents are caused by gas or smoke. The average time from ignition to flashover has gone from 15 minutes in 1950 to three minutes today, because we use more plastics both at home and at work.

Elkem Silicones has over the years developed silicone rubber insulations for electrical cables that significantly reduce the risk of fatalities caused by smoke or toxic substances in case of fire. Bluesil™ FRC 8470 is the latest silicon rubber innovation for electrical and other cables.

The Silicones division tests cables by burning them at temperatures over 900°C for a relatively long time (>30 minutes) to ensure that the insulated sheath does not burn, and that it maintains its protection of the cables. This ensures that electrical or other systems function during fire, which is important when evacuating people.

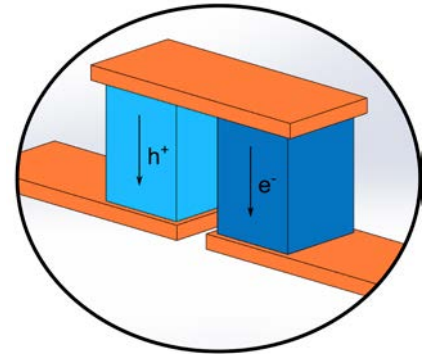
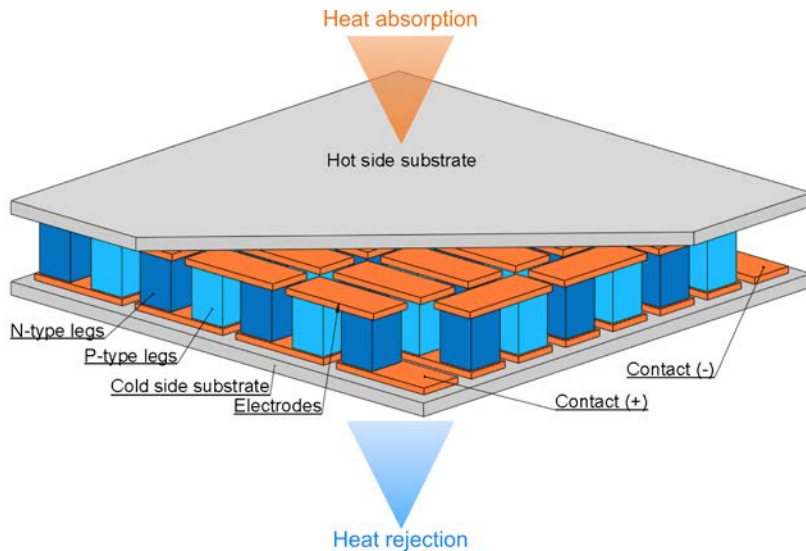
It is important that the rubber does not emit halogen gases when exposed to high temperatures. Halogen gases vary from extremely toxic to somewhat toxic, but are all of great danger to human health.

Elkem Silicones has an established track record in the production of safety cables used in many applications, such as power distribution, safety equipment and telecommunications. The division works closely with customers to provide expert advice and fast-track development services to deliver customized halogen-free silicone rubber (HCR) solutions that meet the performance criteria needed to comply with the most rigorous safety standards.



# Electricity made from hot air

More than 60% of the energy produced in the world today ends up as waste heat. One way to utilise the heat is to let hot air flow through a Thermoelectric Generator (TEG). Elkem could benefit from this both by producing silicon based elements for the TEGs and by using TEG to make electricity at its plants.



A thermoelectric module utilises the seebeck effect to convert a heat flow into electric current or visa versa. It can simply be understood as a solid state heat pump that can be run in both directions.

A TEG-system has no moving parts, requires very little maintenance and, due to its modular design, can be fitted to almost any heat source, regardless of size. The core of a TEG is thermoelectric materials that convert a heat flow into electric current. The higher the temperature difference, the more electricity is generated. However, today TEG technology is relatively costly and in little use, since TEGs are often made of rare, expensive

and even toxic materials.

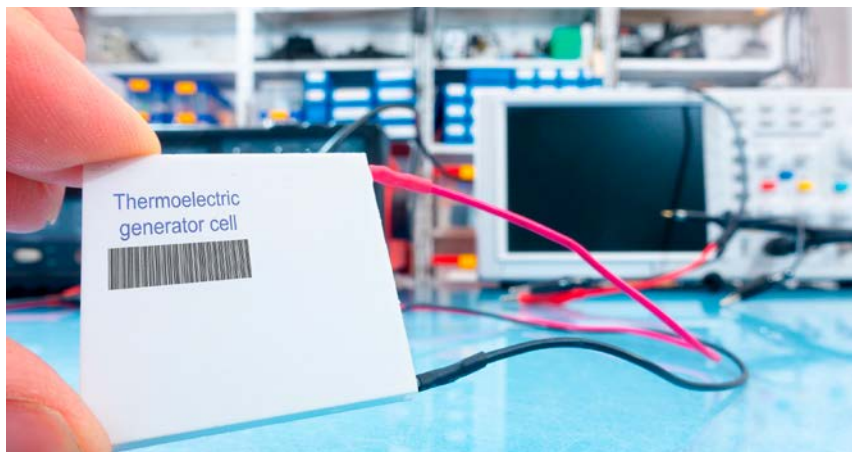
The goal of Elkem's R&D project TESil is to demonstrate that a TEG based on silicides will produce electricity at a considerably lower price than today's TEG technology.

In TESil, Elkem hopes to develop the next generation thermoelectric materials based on low cost and harmless silicon

mixed with other elements forms silicides. The silicides can handle higher temperatures than many of the TEG materials used today, and can therefore convert heat to electricity more efficiently. This also opens up for many new applications, particularly in the field of waste heat recovery, but also as energy harvesters for wireless sensor networks or heat flux sensors and controls.

The next step is to integrate the silicides into a TEG that can be used for waste heat recovery purposes. Since a TEG is a more flexible way of transforming heat into electricity than the generators that are used today at large smelting plants, TEG can be a solution for electricity production at plants of all sizes, all over the world.

Norwegian research partners Sintef, University of Oslo and University of Agder will contribute with important modelling, characterisation and measurement of the silicides to achieve the highest possible efficiency and durability. The project is supported by The Research Council of Norway.



## INNOVATION

# Elkem silicon in lithium-ion batteries

**Li-ion batteries with silicon-based anodes are expected to be the winning technology for electric vehicles. Many companies, including raw material suppliers, fight for a position in this value chain. Elkem has a unique background for developing a high quality silicon solution at competitive cost.**

The reason why introduction of silicon in lithium-ion batteries (LIB) is challenging and takes years of research and development is the expansion that occurs when silicon reacts with lithium during charging, and the corresponding contraction during discharging. To the extent these movements cause crack formation or destroy contact between anode material and current collector, capacity is lost and the number of charging cycles is reduced. If successful, using silicones in batteries can increase the battery capacity tenfold, and results show that a battery with a silicon/graphite anode could do more than 1000 charge cycles.

### Research activities

On-going studies at research institutes

and universities support Elkem in solving the expansion problems by modifying binders, electrolytes, cathodes, additives, etc. The research activities done by researchers in Elkem are focused on micronization and chemistry. This means to establish a process for size reduction, to create a silicon quality with desired structure and purity, which produces repeatable particle sizes and size distributions in the low micron and sub-micron range both in bench and industrial scale equipment.

### 'Green' feedstock

So far, the battery project has resulted in one patent and two patent applications, and Elkem Bremanger produces and supplies commercial amounts of Silgrain®e-Si

to the first customers on a regular basis. The Dutch company 'Smart Green Scans' reported in March 2017 results of the LCA analysis carried out at Bremanger and documented Silgrain®e-Si as a 'green' feedstock to the LIB industry compared to competing raw materials.

### The way forward

The Elkem battery project will end in 2017, and conclusions will be drawn on unit process selection, particle size details, chemistry, etc. With expected project results, Elkem will get an early entry into a promising lithium-ion batteries market.



# Industrialized charcoal production

Elkem has a pronounced goal of using 20% charcoal in the mix of reduction materials in the production of silicon and ferrosilicon alloys in Norway within 2021 and 40% within 2030. To reach this goal Elkem will develop a new industrial process for charcoal tailor-made for silicon and ferrosilicon production processes.

The R&D project PyrOPT is a succession of the R&D project Carbon Neutral Metal Production (CNMP), successfully finished in 2016. CNMP had two aims: Showing that all net CO<sub>2</sub> emissions could be removed by using charcoal, and that the process could be electricity neutral. CNMP proved that, with today's technology Elkem can reach a reduction of 26% of overall energy input, and that 56% of the electricity consumption can be recovered.

The energy reduction and CO<sub>2</sub> emissions targets were achieved by combining charcoal and metal production with energy recovery. CNMP integrates the pyrolysis process for charcoal production with the furnace process for silicon production, and recovers the off-gas energy from both processes. However, the CNMP project also showed that the economic margins are challenging, with a significant dependency on the performance of the pyrolysis technology.

Therefore the PyrOPT project's goal is to improve:

- Charcoal product quality
- Process performance of the pyrolysis technology
- Process integration between the silicon and pyrolysis technology

### Independent of electricity supply

In addition to reducing the emission of CO<sub>2</sub>, a successful realisation of this new integrated technology will improve Elkem's cost position significantly and make it possible to build new silicon and ferrosilicon plants at locations with limited electricity supply.

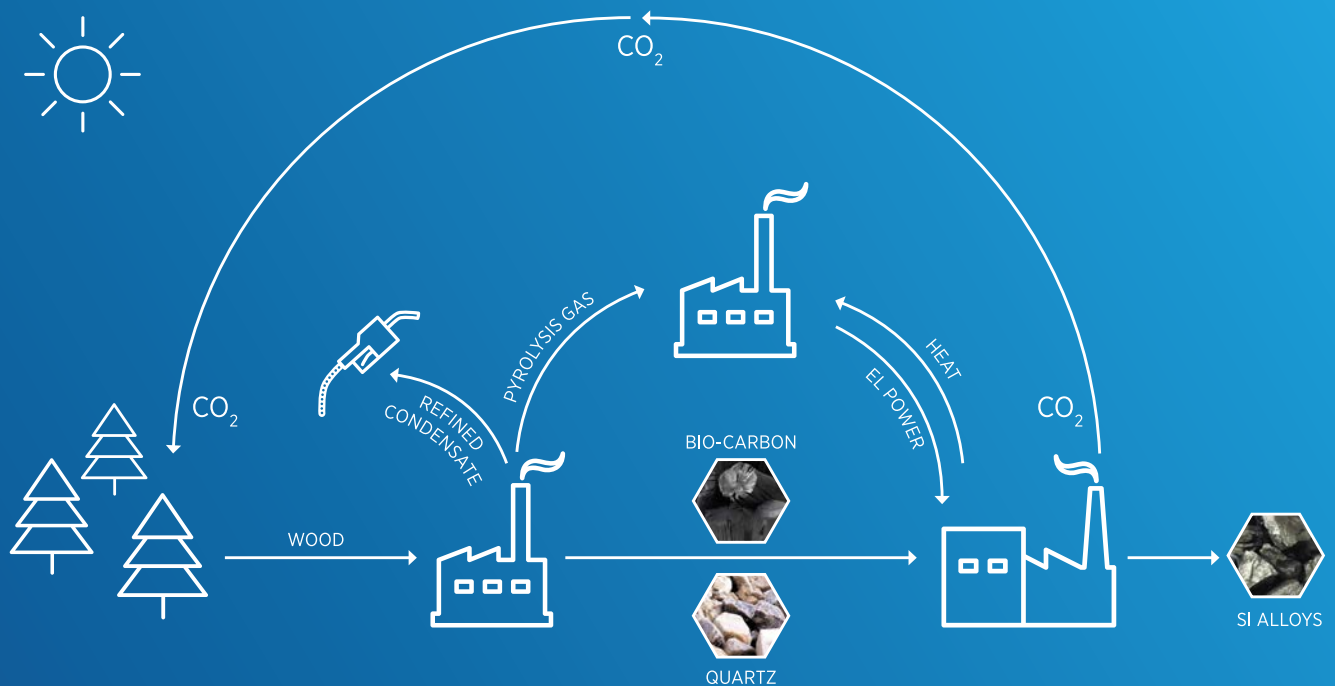
Charcoal is made by heating wood without oxygen, and the products are charcoal, gas and fluids. Elkem needs charcoal with consistent levels of fixed carbon and with mechanical properties that goes well with the entire production flow. Today's charcoal gives a high amount of fine particles that represent an

approximate 15% loss before the material enters the silicon alloy furnace. There are also problems with charcoal fines mixing into the microsilica, an important bi-product in the silicon production process. A set of properties defining a good charcoal will be established as part of the PyrOPT project.

### Exploring other products

The PyrOPT project will also investigate how gas and condensates can be refined to valuable products, other than producing steam or electricity. Possible valuable bi-products are chemicals, biofuel for transportation and binders used in the metal production industry.

The R&D project is organized with Elkem as the industrial partner and with R&D partners SINTEF Energy Research AS (SINTEF ER) and the Paper and Fibre Research Institution (PFI), both in Norway. The project is supported by The Research Council of Norway.





# Controlling emissions by closing the furnace

**SiNoCO<sub>2</sub> is a new R&D programme that will research possible methods for producing silicon alloys with no direct CO<sub>2</sub> emissions from the production furnaces.**

Very simplified, the goal is to ‘close the silicon furnace’. As a result, the off-gas from the furnace will mainly contain CO, which can be further exploited for energy production or chemical manufacturing, such as hydrogen production.

The new production concept could also be an important step on the road to CO<sub>2</sub>-negative silicon production, because it will be possible to use carbon capture and storage (CCS) in addition to the ongoing work to replace coal from fossil sources with charcoal. CCS and ‘carbon negative’ production processes are seen as important contributions to reach the targets defined by the Paris Agreement, which aim at a maximum temperature increase of 1.5°C.

The ‘closed furnace’ will be well adapted for capturing CO<sub>2</sub>, as there will be a high concentration of CO<sub>2</sub> in the final off gas. If fossil coal is replaced with charcoal, it will be possible to take CO<sub>2</sub> out of the atmosphere if a CCS-unit is connected to the plant. The goal is to replace 40% of the fossil coal used in Norway by charcoal by 2030 and towards 100% in the future. Another Elkem R&D project, PyrOPT, (see page 22) will develop a method to optimize a pyrolysis process to produce charcoal with the right properties for silicon production.

## Practical challenges

The biggest challenge for ‘closing the furnace’ is to control the material flow, the energy distribution and the chemical reactions inside the furnace. The silicon process experiences crust formation in the furnace charge, halting the material flow into the metal producing zone further down in the furnace pot. Today, stoking of the ovens solves this problem. When the ovens are closed, a ‘stoking free’ process must be developed or, alternatively, a form of automatic stoking of the furnace.

In addition, the closed furnace must be operated without direct observations of the furnace surface. This is an area that has changed significantly the latest years. Camera technology has been evaluated and industrially tested by Elkem. A closed furnace would have to be equipped with this type of monitoring technology.

If the obstacles are solved, the gains will be large. There is a potential for 40% reduction in energy consumption per tonne of silicon.

## 100% silicon yield

The SiNoCO<sub>2</sub> project will examine whether it is possible to operate a furnace at 100% silicon yield, so that all silicon in the quartz raw materials is tapped as liquid silicon from the furnace, with zero

emission of silicon containing gas from the furnace top.

The off-gas carbon monoxide (CO) from the process can be used for energy production; production of hydrogen or other chemicals, or as a reduction gas for the production of other metals. If successful, what today is waste will be turned into valuable products.

There will be other environmental advantages as well. The NO<sub>x</sub> emissions from the furnace will be reduced by more than 90%. Costs for removing sulphur and other elements will also be reduced. The operational cost of closed furnaces is expected to be 60-70% of the cost level today.

Microsilica is a valuable by-product from present silicon furnaces. Microsilica is the silica fume harvested from the chimneys of today's open or semi-closed furnaces. To identify conditions needed to produce high quality microsilica in closed furnaces is a prioritized activity in SiNoCO<sub>2</sub>.

Elkem Technology is the project owner and manager of SiNoCO<sub>2</sub>. SINTEF, NTNU and Teknova AS are Norwegian research partners in the project. Both Elkem Foundry Products and Elkem Silicon Materials represent future users of the technology. The project is supported by The Research Council of Norway.

## ENVIRONMENT

Opening of the upgraded electricity recovery facility at Elkem Bjølvefossen in March 2016. From the left: CEO in Enova Nils Christian Nakstad, CEO in Elkem Helge Aasen, Minister of Trade and Industry Monica Mæland and plant manager Børge Hauge.



# Elkem's environmental and energy strategy

Elkem works continuously to reduce the company's environmental footprint. Elkem's sustainability philosophy is based on the general principle of producing as efficiently as possible and with the maximum use of all input streams, like materials and energy.

### Audit and report

All divisions and plants are responsible for implementing environmental and energy strategies, and conducting their business in accordance with Elkem's principles in this area. Well established group-wide audit and reporting systems for EHS are also being expanded to include a higher level of focus on environmental and energy issues.

As Elkem continues to grow in new segments of the Silicone value chain, strategic targets in this area include:

- Mapping and understanding Elkem's total environmental impact
- Expanding Elkem's worldwide EHS reporting regime to include better environmental and energy indicators
- Greater understanding of critical emissions and discharges (i.e. COD, dust, CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, PAH), and setting ambitious targets for reduced emissions
- Minimizing the use of landfills and striving to avoid waste through efficient processes and/or recycling into valuable products
- Implementing energy management systems at all sites that have not already done this by end of 2018
- Setting ambitious targets for energy consumption and energy recovery at all sites worldwide



# Energy efficiency and scrubbing measures in Elkem

PROBLEM	MEASURES	WHERE	SOLUTION PROVIDES
<p>Unused thermal energy from production</p> <p>Poor resource utilisation</p> <p>Unnecessary indirect CO<sub>2</sub> emissions</p>	Energy recovery plant	All plants	<p>Hot water and steam for reuse or sale</p> <p>Electricity for sale</p> <p>Better resource utilisation</p> <p>Lower CO<sub>2</sub> emissions</p>
<p>Unnecessary electricity consumption for furnace operation</p> <p>Poor resource and raw material utilisation</p>	Ensuring stable furnace operation and continuous development of optimum furnace operation	All plants	<p>Lower electricity consumption</p> <p>Better resource and raw material utilisation</p>
<p>Unnecessary electricity consumption for plant operations, other than furnaces</p> <p>Poor resource utilisation and higher costs</p>	Energy efficiency measures	All plants	<p>Lower electricity consumption</p> <p>Better resource utilisation and lower costs</p>
<p>Inadequate control of silicon dust from production</p> <p>Local pollution and loss of sellable by-product</p>	<p>Collection of dust in scrubbing system connected to silicon and ferrosilicon furnaces</p> <p>Processes under control</p>	All silicon and ferrosilicon plants	<p>Valuable by-product (microsilica)</p> <p>Less pollution and better quality of life in local environment</p> <p>Better relationship with local community</p>
<p>Inadequate control of dust in the workplace</p> <p>Deterioration of the working environment</p> <p>Wasting sellable by-products</p> <p>Time and resources spent on cleaning and maintenance</p>	<p>Development of production methods for avoiding dust generation</p> <p>New equipment</p> <p>Better extraction and cleaning</p>	All plants	<p>Improved working environment and health and safety results</p> <p>Reduced time used and costs for cleaning and maintenance</p> <p>Sellable by-product</p>
<p>NO<sub>x</sub> emissions</p> <p>Poorer air quality in the local environment</p>	Introduction of new feed method, new furnace design in line with research results	Elkem Salten, Norway	Over 40% lower NO <sub>x</sub> emissions
<p>SO<sub>2</sub> emissions</p> <p>Poorer air quality in the local environment, odour</p>	<p>Use of raw materials with less sulphur where appropriate</p> <p>SO<sub>2</sub> capture and scrubbing</p>	<p>Raw material use in all plants</p> <p>Plans for SO<sub>2</sub> capture at Fiskaa Carbon</p>	<p>Eliminates SO<sub>2</sub> emissions</p> <p>Better relationship with local community</p>
<p>Runoff to the sea and ground of pollutants</p>	<p>Reduced water use</p> <p>Projects reducing pollution of waste water</p> <p>Better control of diffuse emissions</p> <p>Bio-purification of polluted rain water at plants in tropical climates</p>	<p>Elkem Silicones, France</p> <p>Elkem Carbon, Norway and Brazil</p>	<p>Reduced COD emissions</p> <p>Reduced supply of polluted dust into the surroundings that can be dispersed further by water</p> <p>Clean water</p>

# Biocarbon

Using CO<sub>2</sub> neutral biocarbon instead of carbon in the production of silicon and ferrosilicon is a key part of Elkem's sustainable production strategy. Elkem's ambition is that 20% of the company's consumption of carbon as a reduction agent in the smelter process in Norwegian plants shall be biocarbon in 2021, increasing to 40% in 2030.

Elkem already uses biocarbon in the form of charcoal and wood chips in the smelting process at some of its plants and is researching the quality-related and technical aspects of replacing even more carbon with biocarbon. Key questions that need to be answered are how charcoal quality can be optimized, and if and how furnace technology must be customized for the use of more biocarbon in the form of charcoal and wood chips. The whole value chain is involved in the development process to ensure good decisions. See page 22 for information about the R&D project PyrOPT.

Another main challenge is the lack of an international market that can supply the amount of biocarbon for metallurgical usage that is needed to reach Elkem's goal of 40% in 2030. This has led to the conclusion that Elkem must actively look at the possibility of sourcing charcoal from plantations in equatorial countries

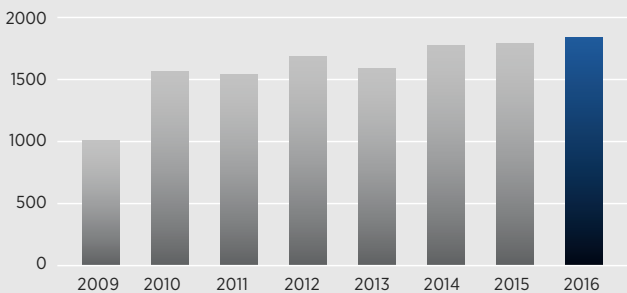
where trees grow rapidly and can provide a basis for industrial-scale charcoal production. While doing this Elkem has also established very strict controls for charcoal suppliers to ensure that timber comes from certified, sustainable sources and that the working conditions in the production process are acceptable and comply with basic human rights. Elkem has zero tolerance of corruption and non-compliance with laws and regulations. Read more about Elkem's supplier requirements on page 41.

A third challenge is found in logistics. Biocarbon in the form of charcoal and wood chips, is a voluminous product. To reduce costs and the negative environmental effects of long transportation, Elkem ideally seeks biocarbon sources located close to the plants where it will be used. In South America this is possible and there are already well-established structures for charcoal production in

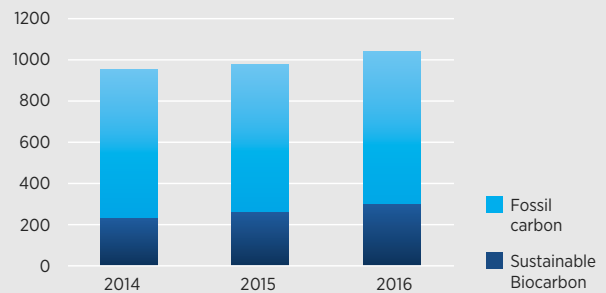
place. The climate is also ideal for plantation production of timber for charcoal production: It only takes seven years for a eucalyptus tree to grow to full size. For Norway this is more challenging as it takes 30 years for a tree to grow to full size. Charcoal production may, however, still be feasible in Norway as there are substantial amounts of forest wood that is no longer being utilised in other industries and needs to be harvested to make room for new growth. Elkem is therefore also exploring charcoal production in Norway, where several of Elkem's largest plants are located.

A study done in 2016 by Elkem in cooperation with several other Norwegian companies confirmed that it would be possible to make charcoal from Norwegian spruce. There are, however, still a number of issues including long term timber availability and pricing that need to be resolved before production can be initiated.

CO<sub>2</sub> emissions Elkem group 1000 tonnes/year



Reduction material Elkem group 1000 tonnes/year



## ENVIRONMENT

# Monitoring water bodies

**During 2015 and 2016 Elkem plants in Europe have systematically monitored the environmental status of their surrounding water bodies.**

Elkem's water monitoring programmes are in compliance with the EU Water Framework Directive. Water monitoring has, however, been an on-going activity for Elkem's plants for a decade or more. Several plants have been monitoring sediments, biota and water bodies potentially affected by production plants.

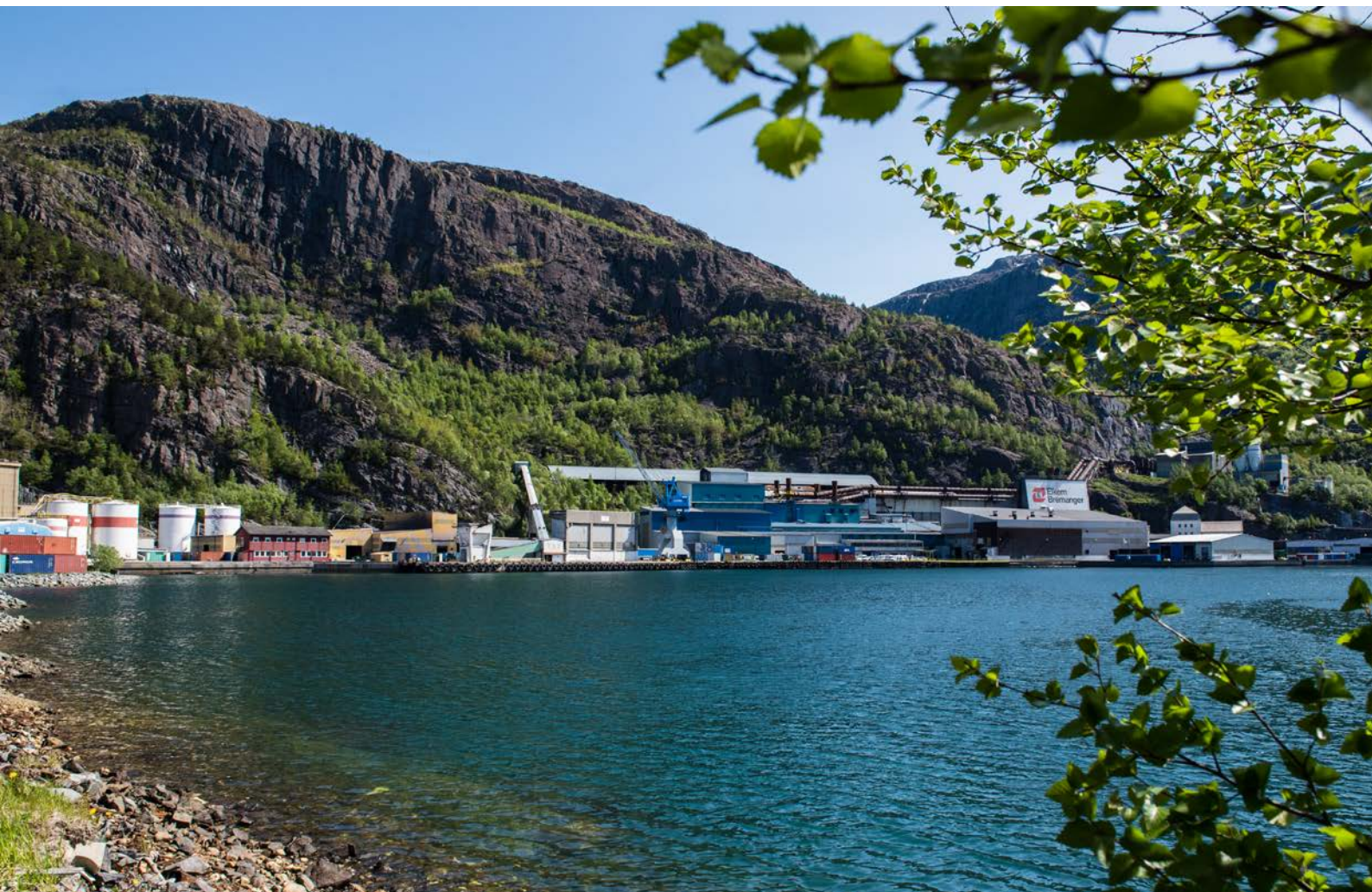
The monitoring programmes carried out by Elkem Salten, Elkem Thamshavn and Elkem Bjølvefossen were mainly designed and performed to monitor possible run-off from existing or previous landfill sites, whereas the Elkem Carbon's and Elkem Bremanger's monitoring programme was designed to take into account potential effects of regulated discharge to water.

Elkem Iceland has a joint monitoring plan with Century Aluminium for the industrial site at Grundartangi. In this monitoring plan Icelandic water regulations are used to determine compliance for drinkable water. Fresh water samples are collected from five rivers near the industrial site where the mean concentration of fluorine, chloride and sulphate has been below values specified in Icelandic regulations. Heavy metals are monitored in sea water, sediments and blue mussels. PAH16 is monitored in blue mussels and sediment in Iceland. All values are low and below the Norwegian environmental limits.

The water monitoring results were mostly as expected. Results are excellent for plants established less than 40 years ago, and the tests are showing improved

overall results compared to earlier tests. Results for water bodies that have been exposed to silicon and ferrosilicon production exclusively, generally show good results. Key parameters like levels of heavy metals and organic compounds in blue mussels and sediment levels from landfill run-off at Elkem Salten, Elkem Bjølvefossen and Elkem Thamshavn seem to be very low. The environmental status of the Nordgulen (Elkem Bremanger) and Kristiansand fjords (Elkem Solar and Elkem Carbon) are more complex, due to various past and present activities from both industrial plants and the local community.

For water bodies that are at risk of not achieving satisfactory results within 2021, risk-reducing measures will be implemented.

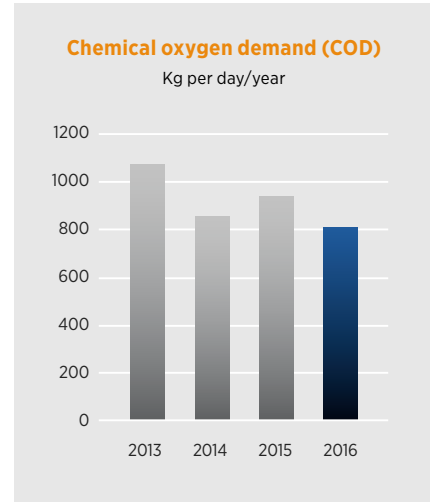


# Water management in silicones production

Elkem's Silicones division does not have a standalone water policy. Water management issues are included in the Responsible Care Global Charter to which the Silicones division is a signatory. All silicones plants have permits, which limit effluent discharge and define daily limits for discharge volume, flow rate and concentration of pollutants. The parameter used is chemical oxygen demand (COD), expressed as metric tons of oxygen. COD emissions are measured at all plants and analyzed and managed daily. A monthly environmental review is organized at plant and board level for the French plants as they represent around 99% of the Elkem Silicone's effluents.

In addition to compliance with local environmental permits, continuous improvement in both water use and COD reduction is the goal. Several improvement projects have been initiated during the last 3-4 years. Some examples are:

- Several contaminated water discharges have been stopped and are now incinerated
- Installation of dry vacuum pumps instead of water vacuum pumps and reliability programmes
- Optimisation of pH treatment to remove soluble copper before discharge
- New distillation column to reduce volatiles



# Water economizing in Elkem Carbon

Efforts are on-going at all Elkem Carbon plants worldwide to reduce the amount of water used in production. Plants located in areas where water is a critical resource have special focus on water economization.

Elkem Carbon is using water for cooling the products, but also to cool down technical equipment like transformers, high temperature furnace processes and rotating equipment like ball mills for generation of fine materials. These systems do

not imply any contamination of the water.

Elkem Ferroveld, South Africa, has up-graded the closed loop cooling system with state of the art sensors and control systems. The pipelines are replaced to ensure safe operation of the control instruments. The water is circulating through closed systems with cooling panels and heat exchangers made of steel. The temperature of the water will increase and then pass through separate coolers. Air coolers gives a loss of water

by evaporation, but the water loss is significantly reduced compared to previous open and free-flow coolers.

The plant in the Ningxia Province in China, close to the Gobi desert, is now connected to the public water supply, ensuring the required water quality needed for the cooling process. Water at this plant was previously taken from ground water wells, which required more maintenance due to contamination and corrosion of the water pipelines.



## Substantial NO<sub>x</sub> reductions

The rebuilding of two furnaces at Elkem Salten and one at Elkem Thamshavn in Norway has reduced Elkem’s emissions of NO<sub>x</sub> with nearly 1,300 tonnes per year. Planned rebuilding of two more furnaces will cut emission with another 400 tonnes a year.

Nitrogen oxides (NO<sub>x</sub>) are gases that lead to higher concentrations of tropospheric ozone, acid precipitation and global warming. These emissions can be harmful to ecosystems and vegetation, as well as health. In Norway, the transport sector accounts for 58% of emissions, while the industry accounts for 11%.

The formation of NO<sub>x</sub> takes place in the furnaces at temperatures above 1,500°C. Understanding the processes behind the formation of NO<sub>x</sub> has made it possible to redesign the furnace hood on Elkem’s smelting furnaces in order to reach a significant reduction of the emissions. As one of the largest single emitters of

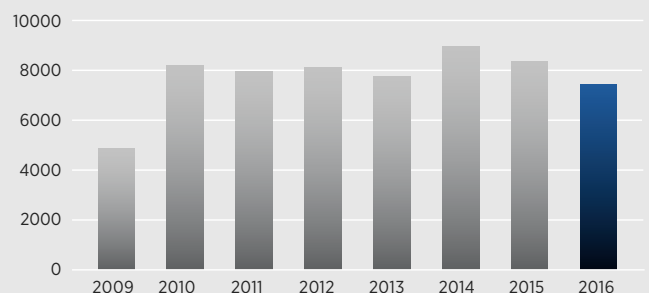
NO<sub>x</sub> in Norwegian land based industry, Elkem has performed intensive studies together with different research institutions and full-scale testing at Elkem Thamshavn and Elkem Salten to develop technology that can give a substantial reduction in emissions of NO<sub>x</sub> from the smelting process. With financial support from the Norwegian NO<sub>x</sub> Fund the technology has been rolled out on three furnaces giving a reduction of almost 1,300 metric tons NO<sub>x</sub> per year. Two other furnaces will also be rebuilt in the near future giving a total reduction of NO<sub>x</sub> emissions of approximately 1,700 tonnes, which equals the NO<sub>x</sub> emission of approximately 340,000 cars, based on an

average NO<sub>x</sub> emission from a car of about 5 kilogram per year. The total investment in the rebuilding projects exceeds NOK 300 mill.

In addition to furnace design, furnace operation and product type also have an effect on NO<sub>x</sub> emissions. More NO<sub>x</sub> is formed at higher temperatures which are generated when producing silicon with higher purity. As the market demands more speciality products with a higher silicon purity some of the environmental gain may be lost, but Elkem is still working actively to ensure that increases are as low as technically possible.



Emissions NO<sub>x</sub> Elkem group Tonnes/year



# Combatting dust in the work environment

**Elkem allocates significant resources to combat silicon and ferrosilicon dust in the work environment. The long-term goal is to reduce process dust to levels where exposure is acceptable without the use of respiratory protection.**

Extremely high temperatures and ultra-fine particles that disperse very quickly makes it especially difficult to capture dust generated during the tapping and casting processes. Elkem, together with R&D partners have successfully gained greater understanding of these challenges and developed better solutions for dust collection near sources with gas temperatures of up to 1,400°C.

## Effective dust collection in the tapping area

The tapping area has one of the most difficult emission points for combatting dust in a smelting furnace building. Therefore, for the past 4-5 years, Elkem has been developing new types of highly effective local dust collection and extraction systems for the tapping area. As each furnace is unique with respect to processing and structural conditions, the technology must be tailor-made for each furnace.

The technology has now been installed at several Norwegian plants:

- An industrial pilot was installed on

the Thamshavn furnace number 1 in 2013. Unfortunately, filter capacity has not been sufficient to fully realize the potential of the improvement. This will be resolved in 2017 when new filter capacity will be installed.

- After meticulous planning and design work, the technology was also installed on the Bremanger Foundry furnace number 4 and put into operation in January 2016. This solution included an air curtain system as a supplement to prevent tapping smoke from escaping. This add-on was successful, and further development work is ongoing to improve the design and utilization of air curtain technology.
- The Foundry division followed up by copying and installing the same equipment on their second furnace in Bremanger in June 2016.
- A detailed plan for further deployment of the technology in Elkem is in place:
  - › Salten furnace number 2 is planned for Q4 2017
  - › Design solutions are developed for the Elkem Thamshavn furnace number 2 and for the Elkem Salten furnace number 1

- › A concept design solution for the Elkem Rana furnace number 5 is currently under way

Available extraction and filter capacity in connection with the collection and extraction system on furnace numbers 2 and 4 at Bremanger has also opened for a similar solution on a recently installed refining station ensuring that new emissions are correctly taken care of and not let out in to the working area.

## Casting

Elkem is also working on the development of extraction hoods for capturing process gas during casting. This is even more challenging than the tapping area because casting involves several moving systems and multiple points of dust generation. A preliminary study has been done at the Salten plant in Norway and is ready to be followed up with a pilot installation. Elkem Bremanger is also working on new casting technology that will reduce dust generation and emissions.



Installation of an air curtain system as a supplement to prevent tapping smoke from escaping.



### Plans for further reduction of dust in the working environment

All of Elkem's Norwegian (ferro-)silicon plants have developed detailed plans regarding reduction of dust generation, improved dust collection and reduced personnel dust exposure.

Tailormade extraction/collection systems will be implemented at all plants, and online dust measuring equipment will also be installed, so that all dust sources in the production halls can be identified, measured and, if possible, eliminated. Focus is also on how working routines and equipment can be changed to reduce or eliminate the generation of dust and exposure to it in the working environment. Results and ideas are shared across the divisions.

### Research on respiratory protection equipment

Elkem is partner in DeMaskUs, a four-year research project focusing on optimal use of respiratory protection in the smelter industry. The project started in 2015 and is an interdisciplinary research project aiming to identify sources and dispersion of ultrafine particles in the Norwegian ferroalloy and silicon carbide industries, their effect on anyone exposed to them, and how exposed workers can effectively be protected.

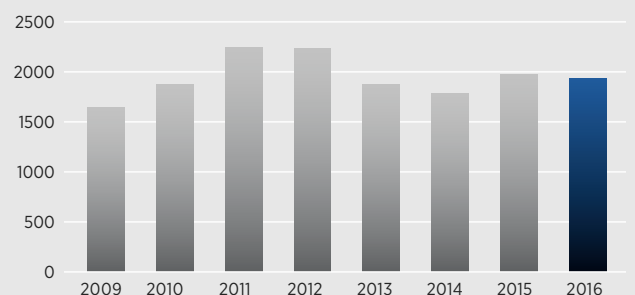
The focus is on personal respiratory protection equipment and human behaviour. The DeMaskUs project is researching the effectiveness of various dust masks against ultrafine particles. It is also looking at the psychological factors that may affect how people use personal protection equipment. Studies have illustrated that factors such as knowledge, attitude, behaviour, individual differences and

work place culture are important predictors with regard to whether respiratory protection equipment is actually used. The final goal of these investigations is to be able to achieve intervention strategies that better facilitate desired behaviour and thus increase the probability of actual and correct respiratory protection equipment use.

'Fit testing' of respiratory protection has been used actively at Elkem's Norwegian silicon and ferrosilicon smelters over the past few years to increase correct use of this type of protection among exposed employees. During the testing employees are instructed in the correct use of the equipment and given the opportunity to try different types of masks to find the optimal fit for the shape of their face. The DeMaskUs project has enhanced this through mapping of possible psychological factors with questionnaires filled out by employees and studied by researchers.

The DeMaskUs project is a collaboration between SINTEF, NTNU, St. Olavs hospital, University hospital of North Norway, University of Tromsø, The Norwegian Institute of Occupational health, and the Norwegian ferroalloy and SiC industries. The Norwegian Ferroalloy Producers Research Foundation (FFF) and the SiC producers Saint-Gobain and Washington-Mills, in addition to the Norwegian Research Council through the Nano2021 programme, fund the project.

Emissions of dust Elkem group Tonnes/year



# Major reduction in SO<sub>2</sub> emissions

Elkem Carbon has been granted funding to clean sulphur emissions from its calcination furnaces at Fiskaa, Norway. Construction work is well underway. When the project is completed, sulphur emissions from the furnaces that process petroleum coke will be reduced by 98%. The total emission of SO<sub>2</sub> from this plant will thereby be reduced by over 50%. The facility is scheduled for completion in September 2017.

The project has an investment budget of NOK 141 million and is co-funded by the Norwegian Environment Fund, ENOVA and Elkem. Three of the plant's 13 calcination furnaces are used to process petroleum coke. The project is limited to these three furnaces as they represent about 60% of the total SO<sub>2</sub> emissions from the plant and will therefore give the highest possible improvement for the available funding.

### Energy recovery

At the point of emission, furnace off-gas from a calcination furnace has a temperature of approximately 1,000°C. This is too high for a sulphur cleaning system and must be reduced to about 200°C before

entering the cleaning process. Years of research and testing at Elkem's Carbon plants have shown that this energy does not have to be wasted, but can be recovered in a combined energy recovery and sulphur treatment plant.

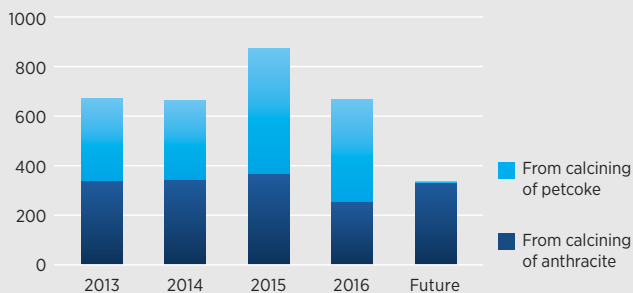
When the project is completed, it will recover 18-20 GWh of heat energy per year from the furnace off-gas. This will be used to lower electricity consumption in other parts of the production. Equipment installed by the project will lead furnace off-gas through a heat exchanger to heat up oil. The hot oil is used to keep pitch in a liquid state during storage and hot enough to flow through the different production processes. Elkem Carbon uses pitch in the production of electrode

paste, among other things. Excess heat will also be used to dry another raw material, anthracite, before the calcination process, so that less energy is required to remove moisture during this part of the process. A warehouse for the storage of raw anthracite has already been built, making it possible to keep the anthracite protected from rain and moisture when dried.

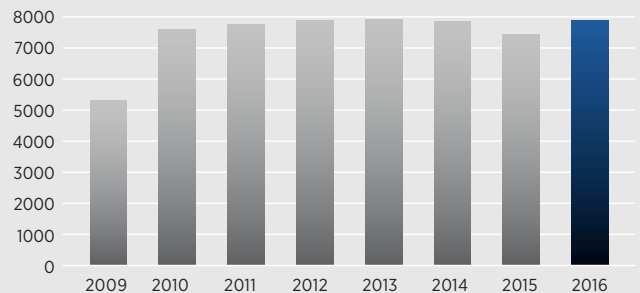
In addition to thermal oil heating and anthracite drying there will also be a substantial amount of heat energy available for other initiatives to replace electricity and oil as sources of heat for offices and other buildings in Elkem's industrial area at Fiskaa in Kristiansand.



Emissions of SO<sub>2</sub> Tonnes/year



Emissions of sulfur Elkem group Tonnes/year





# Sustainability initiatives at Elkem Silicones Shanghai, China

In recent years, the Chinese government has frequently issued new environmental regulations and laws. Air quality is a major concern.

Over the past decade, the Chinese economy has achieved impressive results. However, the pressure on energy resources and the environment has been heavy. As a consequence, the environmental awareness of the Chinese people and the Chinese government has increased. The Chinese government will further tighten the environmental demands on companies' progress in the 13th Five-Year Plan, operative for the period 2016-2020.

Over the past years, Elkem Silicones plant in Shanghai has been committed to reduce its environmental footprint. In 2012, the plant implemented a clean production initiative, followed by the renovation of the ventilation systems in its workshops. In 2015, the plant made substantial investments in its pollution control systems installing new absorbers in addition to existing activated carbon absorbers, and implementing world-class LDAR (Leak Detection and Repair) methodology to further reduce VOC (volatile organic compounds) emissions from valves, pumps, mixers, compressors, flanges, connectors and so on. As a result, the plant managed to comply with new requirements under the 'One Plant, One Scheme' programme required for 150 key enterprises in Shanghai earlier than mandated.

To meet the introduction of new regulations from 1 January 2017, the plant launched another series of environmen-

tal initiatives at the end of 2015 under the guidance of Shanghai Municipal Environmental Protection Bureau, Shanghai Academy of Environmental Sciences and other experts. After rigorous project assessment, technical discussions with French experts as well as on-site inspection and comparisons among suppliers, RTO (Regenerative Thermal Oxidizer) technology was selected to destroy emissions from one of the main production processes at the plant.

The RTO technology destroys Hazardous Air Pollutants (HAPs), Volatile Organic Compounds (VOCs) and odorous emissions that are often discharged from industrial or manufacturing processes and converts pollutants into carbon dioxide and water vapor. On site it is now used to destroy the waste gas generated from the manufacturing of toluene-containing products for release coating applications. With a total investment of two million RMB, the equipment has ensured a remarkable reduction in emissions:

- VOC emission to less than 10ppm, which fully satisfy the new regulation
- The concentration of NMHC (non-methane hydrocarbon) is 1.8 mg/m<sup>3</sup>, well under the legal limit of and 50 mg/m<sup>3</sup> for NMHC
- Concentration of toluene is 0.704 mg/m<sup>3</sup>, also well below emission limit value of 10mg/m<sup>3</sup>

Elkem Silicones Shanghai has also taken a series of actions to reuse and reduce its energy consumption, and to reduce waste and wastewater from the production. Thanks to these initiatives, the plant has both reduced its fixed costs and the environment footprint, and can offer its employees a cleaner and better working environment.

- In 2014, the plant started to use hot water generated from the production process as bath water offered to operators in the winter
- In 2015, the plant installed a non-electrical air conditioner that could use available steam at the factory site for cooling, thus reducing electricity consumption
- From 2015, the plant has used a sand filter, carbon filter and RO membrane filter to produce de-ionized water, thus increasing the production of de-ionized water with 50%
- In 2016, the company started separating generic waste and solid waste. A project team was set up to reduce solid waste treatment cost. Reduction in solid waste the first year was more than 20%, saving 200,000 RMB

## Regulation

## Date

Regulation	Date
People's Republic of China Air Pollutant Emission Standard	01.01.1997
Shanghai Clean Air Action Plan (2013-2017)	07.11.2013
Smell Investigation Rectification Opinion in Xin Zhuang and Zhuanqiao zone	01.01.2014
Shanghai Top VOC Emission Enterprises 2014 - One Plant, One Scheme	04.04.2014
People's Republic of China Environment Protection Law	01.01.2015
People's Republic of China Air Pollution Prevention Law	01.01.2016
Shanghai Air Pollutant Emission Standard	01.01.2017



PAH emissions to water from Elkem Carbon Fiskaa, Norway have been heavily reduced from 650 kg in 2004 to around 2 kg per year in 2016.



## Phasing out PAH

Elkem Carbon’s main R&D priority is to develop products that are PAH (polycyclic aromatic hydrocarbons) free.

Elkem Carbon is a world-leading supplier of carbon electrode materials, lining materials and specialty carbon products to metallurgical processes for the production of ferroalloys, base metals and primary aluminium.

Elkem Carbon uses coal tar pitch as a binder in its products. Coal tar pitch contains PAHs - polycyclic aromatic hydrocarbons. Several of the PAH compounds are classified as health hazards and substances of very high concern. The large volumes of such binders (4 million tonnes annual consumption worldwide) also constitute a substantial contribution to greenhouse gases, since it is oxidized to CO<sub>2</sub> during metal production. In December 2016 the European Union made the use of coal tar pitch subject to

authorisation. Intermediate use, like in electrode paste for use in smelting processes, is exempted from authorisation.

### R&D

Research to find alternatives to coal tar pitch is a priority for Elkem Carbon. By developing products that do not contain coal tar pitch, Elkem Carbon will minimise PAH exposure and emissions both from its own production and from the customer’s production of aluminium, ferroalloys and other metals.

### BIOFOREVER

A consortium of 14 European companies using EU funding under the Horizon 2020 programme, is planning to demonstrate the conversion of woody biomass to value

adding chemical building blocks. Elkem Carbon will focus on demonstrating the application of the chemicals as binders in their products.

Knowledge and experience from Elkem’s work on ELSEAL® Type G will be used in this project to verify if different materials available from the bio refineries can be used as binders in carbon materials for the metallurgical industry.

### Green binder for carbon products – supported by the Norwegian Research Council

The overall goal of the ‘Green binder for carbon products’ project is to develop biobased binders for carbon products to replace today’s fossil based coke tar binders. This will, if successful, reduce the CO<sub>2</sub>

footprint of the metallurgical industry and also improve its working environment.

Elkem Carbon and the Norwegian bio refinery Borregaard have joined forces in this project. Borregaard will tailor-make bio based binders with optimized properties for use in carbon products. Elkem Carbon will test the new binders in both their pilot and full scale facilities, and make the necessary adjustments and optimizations to make use of these novel green binders in their commercial manufacturing processes possible.

### Reduced waste

To avoid unnecessary disposal of waste containing PAHs, Elkem Carbon is working systematically to recycle scrap production in the production of new products. It has invested in new equipment to handle and process off-spec materials. The rejected products are crushed, sieved and fed in controlled quantities into the production process through a separate silo.

### Reduction of PAH emissions to air

Elkem Carbon Fiskaa, Norway, aims to keep its emissions of PAH under 50% of what is permitted in their environmental permit, even with increased production. A stable production process in a

well-maintained facility is important to reach this goal. Systematic work to reduce dust has had a strong positive impact on Elkem Carbon's PAH emissions to air. The vast improvements have given room for less use of personal respiratory protection, as the air in the working environment is safe to breathe. The reduction of PAH emissions to air from the plant continued in 2015, but a slight increase was registered in 2016. The root cause for the 2016 increase has been identified as a change in raw material quality.

Elkem Carbon, Fiskaa, Norway is participating in a national survey on moss quality in the areas around Norwegian production facilities. This includes determination of PAHs and metals in moss and PAHs in air. Since 1983 and every year from 2010 Elkem Carbon Fiskaa, Norway has been monitoring the water and sediment quality for PAHs in the neighbouring fjord (Kristiansandsfjorden). After 30 years of warning against eating fish from the fjord, the Norwegian Food Safety Authorities now considers fish from the Kristiansandsfjord safe to eat. Results for blue mussels and sediments are also improving.

### Reduction of PAH emissions to water

Efforts are ongoing at all Elkem Carbon

plants worldwide to reduce the amount of water used in production. The reduction of PAH from 650 kg to less than 2 kg have been achieved through extensive maintenance on the water pipes to avoid leaks, and new piping has been installed, in order to separate water streams into clean cooling water and contaminated water. This makes it possible to treat the contaminated surface water and measure emissions.

Elkem Carbon Ferroveld in South Africa has an integrated process-water treatment system on site. Contaminated water from the extruder facility is transferred to process-water used for cooling chrome slag at another production facility in the industrial park. In this process contamination is destroyed and water evaporates instead of being discharged.

In tropical regions, biological methods for water purification can be used to remove PAHs and other contamination from rainwater and other storm water. At Elkem Carbon's plant in Brazil, water that may be contaminated is fed through three basins: one containing old wood materials, one containing plants, and one containing bacteria. This purification method is also adopted at Elkem's new plant in Malaysia.

## ELSEAL® Type G

In 2015 Elkem Carbon developed ELSEAL® Type G as an alternative to coal tar pitch based ramming paste. ELSEAL® Type G contains neither PAHs nor other hazardous substances. It is classified as non-hazardous according to present regulations like GHS (globally harmonized system) and the EU/EEA regulations REACH and CLP (classification, labelling and packaging). Hence, there are no emissions of PAHs during production and use, workers will not be exposed to these potentially harmful compounds, and it does not form any harmful waste. ELSEAL® Type G has the same or improved technical performance compared to existing products. It has a proven performance under challenging electrolysis conditions with the combination of high temperature and corrosive bath.



ENVIRONMENT

# Energy leadership



Elkem is constantly seeking ways to reduce energy consumption per produced unit. There are three ways to reach this goal: Increasing the production yield, recovering heat from the furnace off-gases and carefully managing other energy consumption.

Silicon alloy production is energy intensive. In 2016, the electrical smelting furnaces in Elkem consumed 4,364 GWh of electricity compared to 4,314 GWh in 2015. In addition to electricity, the production process requires adding carbon based reduction materials in vast quantities to the process that also represent a large amount of energy.

Elkem recovered 644 GWh of energy in 2016, compared with 483 GWh in 2015. As a percentage of total electricity consumption, the amount of recovered energy was 15% in 2016 up from 11% in 2015.

227 GWh of new electricity was generated from hot off gasses at three plants, one in China and two in Norway. Most of the recovered energy was utilised as district heating, but Elkem Chicoutimi in 2016 sold 227 GWh of steam to the nearby Rio Tinto aluminium plant.

### Energy efficiency

The most effective method to reduce the energy used per produced tonne of ferro-silicon or silicon is to make the production process more energy efficient. Elkem has some of the most energy efficient smelting furnaces in the world, but still sees a potential for improvements. A dedicated research and development project called Si2020 focuses on furnace design, process control, refining, and optimal use of raw materials.

### Energy recovery

There are two main methods to recover energy from the smelting process. Both have their advantages and challenges. The first method recovers energy by utilising surplus heat directly in the form of steam or hot water. This is very efficient, but not very feasible, as most of Elkem's plants are located in sparsely populated areas where there is little demand for heat from local communities or from other industry.

In the second method for energy recovery surplus heat is used to produce electricity. The advantage is that electricity can be fed into the power grid. The downside is that two thirds of the energy is lost in the transformation.

Elkem currently uses both methods. In Norway, Elkem Thamshavn currently generates around 160 GWh of electricity every year, and Elkem Bjølvfossen will increase its generating capacity from 40 to 80 GWh per year, after the recovery facility upgrade was finished in March 2016. At Elkem Carbon in China 35 GWh electricity was recovered in 2016.

Maintaining an intense focus on energy efficiency has made Elkem Thamshavn, Norway and Elkem Chicoutimi, Canada the world's most energy efficient smelting plants for silicon and ferrosilicon production respectively. 70% of the electric energy used at Elkem Chicoutimi in 2016 was recovered as steam and sold for use

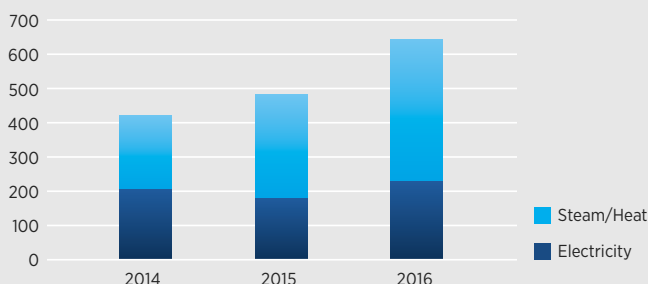
at the neighbouring industrial plant. The main study for a new energy recovery facility at Elkem Salten, Norway, with a potential of recovering 300 GWh/year has been performed, but low electricity prices in Norway have made it difficult to finance the project, which still is under consideration.

At Elkem Carbon's plant in Norway, a combined energy recovery and sulphur treatment plant is under construction. When the project is completed, it will recover 18-20 GWh a year. Waste heat from the calcination furnaces in Elkem Carbon's production will be used to lower electricity consumption in other parts of the production. Read more about the project on page 20.

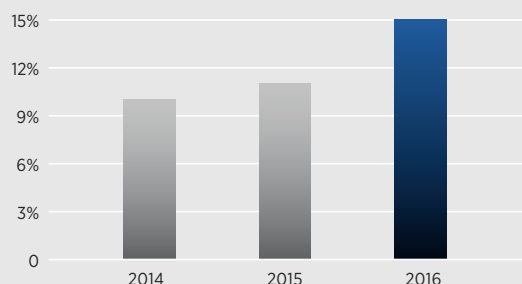
### Energy management

All Elkem plants in the Silicon Materials, Foundry and Carbon divisions now have energy management systems that comply with ISO 50001. The process has showed that even small measures, such as better insulation, motor inspections, lighting management, sealing leaks in compressed air systems, and heating and cooling control, can produce substantial savings, even though each individual measure is relatively small compared with the energy consumption of a smelting furnace. Potential energy savings of 10% of auxiliary energy have been identified.

Energy recovery Elkem group GWh



Energy recovered as % of electricity consumption



# Reducing waste and increasing the yield

**Elkem is finding new ways to reuse materials that previously have been disposed of and will terminate the use of landfills. The reuse of production waste from silicon and ferrosilicon smelters will increase the total yield and improve the environmental footprint of these activities. We also believe that this will result in economic benefits in the long term.**

During different phases of the production process substantial quantities of raw materials and intermediate products must be removed and captured before the final product can be shipped to the customer. Traditionally, much of this has ended up in landfills as reuse has not been feasible either because of material characteristics or cost. Some has also been sold for a low price to customers who have managed to use it in their processes.

With our zero waste philosophy and long term goal of terminating landfills this is no longer acceptable and a number of initiatives have been taken, both to reduce the generation of waste throughout the production process and to reuse any waste that is generated.

## Raw materials

One of the most exciting examples of improved reuse is through briquetting. During transportation and processing

raw materials like quartz and coal are crushed creating a substantial amount of fine materials that cannot be used in the process even though they still contain valuable elements needed in the production. New methods to make solid briquettes from the fines have made it possible to feed the material back into the furnaces and increase the yield. The briquettes are strong enough to tolerate handling and transport and do not crack or break down when fed into the furnace making what was once seen as waste into good quality raw materials. The use of quartz fines in this manner reduces the import of quartz by 10,000-12,000 mt per year, which has led to considerable savings.

## Off-grade microsilica

Another large source of waste has been off-grade microsilica particles captured in the filter process. Off-gas from silicon and ferrosilicon smelting furnaces is cleaned in large filters before emission to

air, giving a valuable by-product called microsilica. During the process, heavier particles are removed using radiclones. Traditionally these particles have been considered worthless even though they contain valuable silicon, carbon and iron units which could be used as raw materials. By turning these into briquettes they can also be used as input when charging the furnaces. Waste is eliminated and yield is increased.

Using these methods some of Elkem's plants are showing tremendous improvement with shares of waste to landfill reduced from 12% to about 5% and increased production yield for quartz about 5-6%.

## Further development

A number of plants, including Elkem Iceland and Elkem Bremanger, are continuously working on new projects to reduce the generation of fines in their production, reuse fines in the process by briquetting or other methods, or to create higher value products from material that was once seen as low value or waste.

One example of creating higher value products from waste is cooperation with Silingen in Poland. In November 2016 Elkem and Silingen signed an exclusive co-operation agreement on product development, production, sales and marketing of FeSi Briquettes to the steel industry. For years, Silingen has been developing and producing high quality FeSi briquettes, mainly using raw materials from Elkem. With the cooperation they will be able to produce up to 18,000 mt per annum.

Elkem will be responsible for the supply of raw materials, as well as sales and marketing of the FeSi briquettes under the brand name BriqSil™. Product development will be a joint effort between Elkem, Silingen and Elkem's customers.





## Product stewardship in Elkem

**Elkem wants to ensure safe handling, use and disposal of our products. Our continuous improvement philosophy means that we constantly look for ways to improve the properties of our products.**

### **Updated product information to customers**

Elkem is committed to complying with international regulatory requirements and provides safety data sheets (SDS) for all its products in accordance with the UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS) or its National implementations.

In all market where Elkem's products are promoted, the products must meet specific requirements and comply with certain technical, health or environmental standards. Elkem's product stewardship team monitors the development of the applicable standards and regulations at the targeted international level in order

to make sure that all Elkem products are compliant at all times.

The majority of Elkem's SDS and product compliance certificates are available for download from Elkem's website ([www.elkem.com](http://www.elkem.com)). However, the SDS for some selected products are only available on request, in order to protect confidential business information.

With a portfolio of approximately 4000 different products that are used in a multitude of applications, regulatory and product compliance is key also for Elkem's Silicones division. Elkem Silicones has therefore developed the document management system OSCAR, which

ensures that compliance, certificates and regulatory statements are easily available for distribution to customers.

The Silicones division is a signatory of the Responsible Care Global Charter of the International Council of Chemical Associations (ICCA). This entails a commitment to managing chemicals safely throughout their life cycle.

### **Innovation to improve product properties**

Elkem's philosophy of continuous improvement also applies to research and development work on new products.

## The issue of D4 and D5

When producing all of the silicone-based end products modern society is so dependent on, a number of chemical processes are used to create intermediate products, which are then further processed to consumer products. D4 and D5 are two of these intermediate products.

Concerns have been raised in some countries as to possible residues from the intermediate products in some of the final products used for rinse-off personal care (like shampoo), and if these could have any negative environmental effects.

### What are D4 and D5?

D4 and D5 are cyclosiloxanes, basic members of the silicone family. As intermediate products they are most frequently used as raw materials in the manufacturing process and only present at low levels in some end products.

### Are D4 and D5 safe for the environment and human health?

The main concerns about D4 and D5 have been in connection with rinse-off personal care products. Critics are concerned that residue will end up in waterways and accumulate over time. Even though public organisations like Health Canada have declared

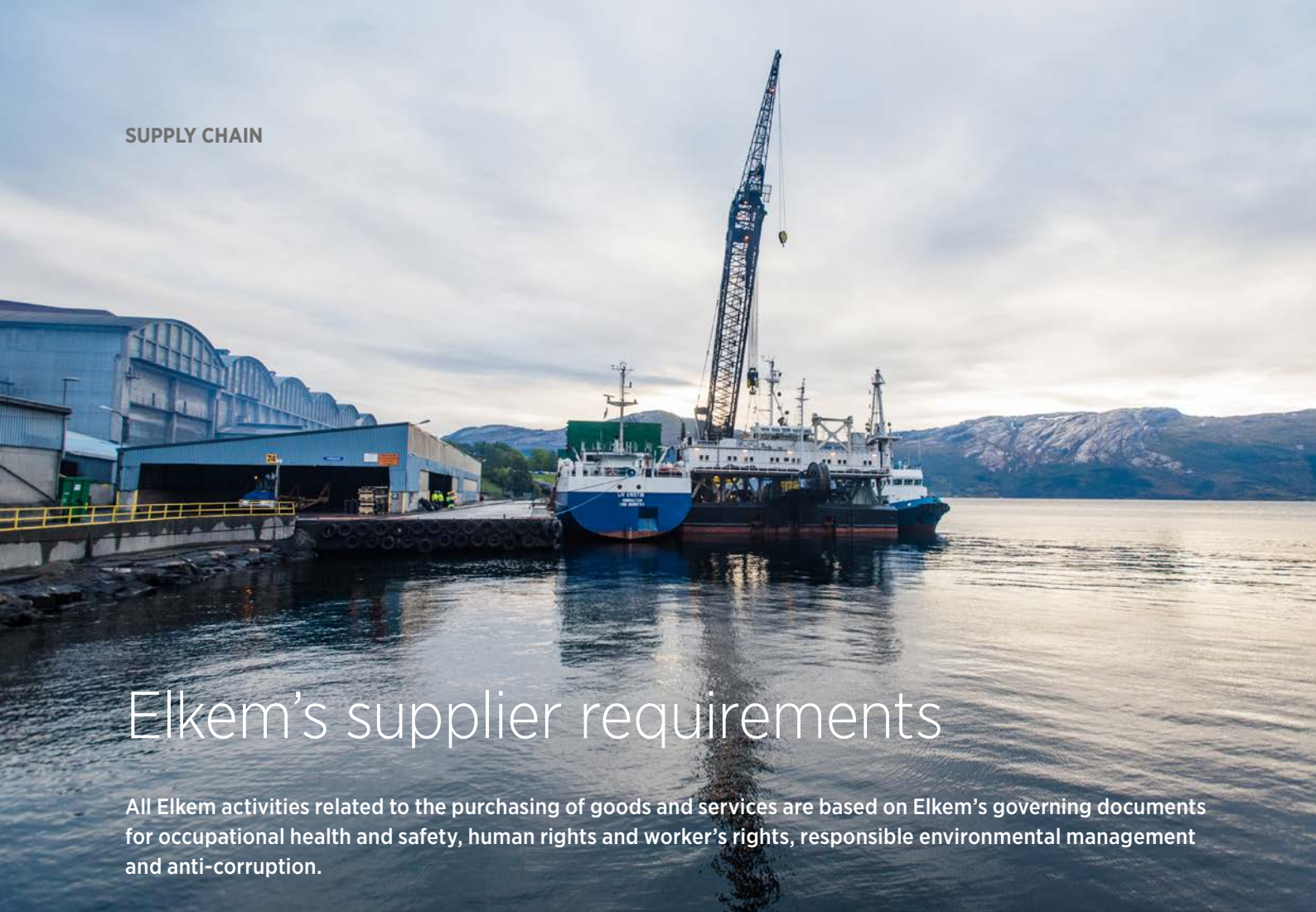
both D4 and D5 safe for human health after substantial independent scientific review and evaluation of how consumers may be exposed to D4 and D5, the possibility of bioaccumulation in the environment has triggered public organisations in other countries to propose stricter regulations around the use of these intermediate products.

In Europe, the ECHA Member States Committee have concluded that D4 and D5 could be regarded as persistent and bioaccumulative under the European Union's chemicals management programme (REACH). Following a proposal by the United Kingdom to restrict the use of D4 and D5 in rinse-off personal care products under REACH, the ECHA's Risk Assessment and Socio-Economic Analysis Committees will evaluate the appropriateness of the proposed Risk Management Measures.

Elkem works closely with the European silicone association (CES) and supports scientific research to fully understand any potentially harmful effects of our processes, intermediates and/or final products. Research is also ongoing to ensure sustainable production if any harm were to be identified or any restrictions implemented on today's processes and products. Elkem is fully committed to complying with existing regulations at all times and to prevent potential harm to the environment.







# Elkem's supplier requirements

All Elkem activities related to the purchasing of goods and services are based on Elkem's governing documents for occupational health and safety, human rights and worker's rights, responsible environmental management and anti-corruption.

New suppliers of raw materials are subject to pre-qualification and risk assessment. Suppliers that fall into 'high risk' categories during the risk assessment are met with specific requirements included in their contracts. Risk-exposed suppliers are subject to detailed requirements from Elkem. Elkem also asks suppliers to influence their sub-contractors and suppliers to follow Elkem's principles.

Suppliers of goods and services are pre-qualified before tendering based on corporate requirements within environment, health and safety, social responsibility and compliance with laws and regulations.

Elkem is developing database and contract management systems to ensure compliance and governance throughout supplies.

## Follow-up

Elkem has developed detailed requirements for the health, safety and environmental standards of our suppliers of operations like mining, transportation, storage and loading, and is actively

involved in the promotion and monitoring of safe and decent working conditions at its high-risk suppliers and contractors. This includes health and safety training and providing correct personal protection equipment for suppliers' employees when necessary. Age control to prevent child labour and ensure responsible working conditions for young employees is also carried out. Elkem requires suppliers and contractors to engage their employees on fair terms, and that they give them information about the ability to organise and collectively bargain with management where this is legally possible.

Elkem's requirements are regularly discussed in meetings with suppliers. High-risk suppliers must document their understanding of legal requirements and hazards in their operations and present plans showing how risk will be eliminated or controlled while working for Elkem. Elkem performs audits and inspections, both in connection with normal visits for sampling and as unannounced site visits. External auditors also conduct supplier audits on Elkem's behalf.

Violations of Elkem's requirements are

registered, and addressed with verbal or written warnings and requests for improvements. Repeated violations lead to requirements for speedy implementation of improvement plans written by Elkem, financial penalties, or termination of contracts with immediate effect.

## Biocarbon

Sourcing of biocarbon is subject to special sustainability requirements. Elkem cooperates with NGOs and academia to secure good understanding of environmental, social and human rights challenges related to biocarbon production in different markets. Elkem requires that suppliers of biocarbon are committed to sustainable and ethical raw material sourcing in accordance with internationally accepted principles and standards (i.e. FSC – Forest Stewardship Council or PEFC – Pan European Forest Certification).

Biodiversity status is reviewed against the International Union for Conservation of Nature (IUCN)/Convention on International Trade in Endangered Species of Wild fauna and flora (CITES).

# Elkem's divisions



# Silicon Materials

The Silicon Materials division manufactures and sells silicon and microsilica for a large number of applications. The division delivers products to customers in the chemical, solar, electronics, aluminium, construction, refractory, oil and gas industries worldwide.



## Key developments and events 2016

Silicon Materials operates four plants in Norway, including Rana, which was acquired in 2016. In addition to silicon metal the division is producing highly specialised microsilica, which is used as an additive in a large number of product applications. The division also has a special focus on raw materials sourcing.

- Silicon Materials has delivered a good financial result despite challenging market conditions
- Sales prices for silicon dropped approx. 30% from May 2015 to June 2016
- Cost reductions and higher sales volumes have partly offset the effects of lower sales prices
- Elkem's plants have a strong competitive position and are among the most cost efficient in the world
- The division is differentiating its product portfolio and has launched several new product applications in 2016
- Elkem Rana, acquired from Fesil, will be integrated in the Silicon Materials division and strengthen the portfolio of differentiated products

### PRODUCTS

**Silicon** produced in different purities and sizes according to customer needs.

**Elkem Microsilica®**, which is used in construction, refractory, oilfield and polymer industries, because of its many unique properties.

### CAPACITY

The division produces approximately 160,000 tonnes of silicon and 275,000 tonnes of microsilica per year.

### PLANTS

**Norway:** Salten, Thamshavn, Bremanger and Rana

### QUARTZ MINES

**Norway:** Tana, Mårnes,  
**Spain:** Explotacion de Rocas Industriales y Minerals SA (Erimsa)

### KEY NUMBERS

	2016	2015	Share of group 2016*
Revenue NOK million	4,540	4,759	32%
Employed FTE (full-time equivalent)	899	793	24%

\* The division's share of the group revenues is calculated including the division intra group transactions.

# Silicones

The Silicones division produces siloxanes and a comprehensive range of silicones, which are a family of specialty, high performance products and materials, produced by reacting silicon with methyl chloride. Silicones are found in a large variety of products used in daily life. Elkem Silicones division is one of the leading producers of airbag coating, paper coating and other specialty products such as defoamers and lubricants.



## Key developments and events 2016

Elkem Silicones operates two major plants in France for production of upstream and intermediary products. In addition, the division has production facilities in Europe, North America, South America and Asia for production of specialised silicones products.

- Good sales volumes and strong development in Asia
- Improved cost position due to vertical integration with Elkem
- Production problems, mainly in second quarter, due to interruption of supply of a key raw materials and some strikes in France
- Tragic accident at the Saint-Fons plant end of Q2 with one fatality
- Increased sales of specialities, continued strong focus on R&D and product development
- Brazilian operation relocated and upgraded in 2016 and launch of a completely revamped workshop for Elastomers in Saint-Fons

### PRODUCTS

Silicones produced by the division are found in products such as release coatings, rubber, textile coating, healthcare, personal care, mould making, speciality fluids, sealing and bonding and construction.

### CAPACITY

The division has an upstream capacity of about 100,000 tonnes per year of siloxane and more than 250,000 tonnes capacity per year of intermediates and silicones.

### PLANTS

**France:** Roussillon, Saint-Fons  
**Germany:** Lübeck  
**Italy:** Caronno  
**Spain:** Santa Perpetua  
**USA:** York  
**China:** Shanghai  
**Brazil:** Joinville

### KEY NUMBERS

	2016	2015	Share of group 2016*
Revenue NOK millions	5,029	4,985	35%
Employed FTE (full-time equivalent)	1,401	1,499	37%

\* The division's share of the group revenues is calculated including the division intra group transactions.

# Foundry Products

The Foundry Products division provides metal treatment solutions to iron foundries and is a supplier of high quality speciality ferrosilicon to the steel industry. The automotive, engineering, pipe and steel industries are important markets for the division.



## Key developments and events 2016

Foundry Products has a strong global production footprint with plants in Norway, Iceland, Canada, China and India. In addition, the new plant in Paraguay is expected to start production in 2017. The division has a high share of specialised products for the foundry industry.

- Foundry Products delivered record sales and production volumes in 2016
- Sales prices for ferrosilicon dropped approx. 29% from April 2015 to March 2016 and has negatively affected the financial result for 2016
- A number of strategic projects have been concluded in 2016, including acquisition of a foundry alloy plant in

- India and the construction of a new plant in Paraguay
- The plant in China will be relocated in 2017 to increase the production capacity
- In addition, the division has completed a successful rebuild of furnace 2 at Bremanger and installed a new turbine for energy recovery at Bjølvfossen

### PRODUCTS

The division is a supplier of high quality speciality ferrosilicon and provides metal treatment solutions to iron foundries.

### CAPACITY

The division has a total production capacity of approximately 265,000 tonnes per year, based on its current product mix of ferrosilicon-magnesium (nodularisers), inoculants and ferrosilicon.

### PLANTS

- Norway:** Bremanger and Bjølvfossen
- Iceland:** Akranes
- Canada:** Chicoutimi
- China:** Shizuishan
- India:** Nagpur

### KEY NUMBERS

	2016	2015	Share of group 2016*
Revenue NOK million	3,642	3,674	26%
Employed FTE (full-time equivalent)	734	626	19%

\*The division share of the group revenues is calculated including the division intra group transactions.

# Carbon

The Carbon division produces carbon materials. The main products are Söderberg electrode paste, lining materials, pre-baked electrodes and specialty carbon products for various metallurgical smelting processes and primary aluminium industries.



## Key developments and events 2016

The Carbon division has production facilities in Norway, Brazil, South Africa, China and Malaysia. The division has leading positions in most of its markets and a strong fundament for growth based on global strategy and synergies.

- Strong financial performance for the division
- New plant in Malaysia commenced production
- High focus on health and environment with a number of strong initiatives
- Ambitious cost reduction targets through EBS and automation
- Product development to meet new growth segments
- Systematic plan to reduce time to market through streamlining product development processes

### PRODUCTS

Söderberg electrode paste, lining materials, pre-baked electrodes and specialty carbon products for various metallurgical smelting processes and primary aluminium industries.

### CAPACITY

Carbon has an annual production capacity of approximately 260,000 tonnes of Söderberg electrode paste and approximately 105,000 tonnes of other carbon products, depending on the product mix.

### PLANTS

**Norway:** Kristiansand  
**China:** Shizuishan  
**Malaysia:** Sarawak  
**Brazil:** Carboindustrial and Carboderivados, Vitoria  
**South Africa:** Ferroveld JV, eMalahleni

### KEY NUMBERS

	2016	2015	Share of group 2016*
Revenue NOK million	1,375	1,388	10%
Employed FTE (full-time equivalent)	420	409	11%

\* The division's share of the group revenues is calculated including the division intra group transactions.

## About this report

Elkem is reporting according to the Global Reporting Initiative-guidelines (G4/Core). When addressing sustainability issues, Elkem puts great emphasis on input from stakeholders (see page 12). Based on this input, and a broad knowledge of Elkem's sustainability challenges and possibilities, Elkem's CSR committee (see page 10) considers the following aspects the most material for Elkem:

- Energy
- Emissions
- Product responsibility
- Occupational health and safety
- Supplier performance regarding environment and labour practices
- Anti-corruption and anti-competitive behaviour
- Relations with local communities



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