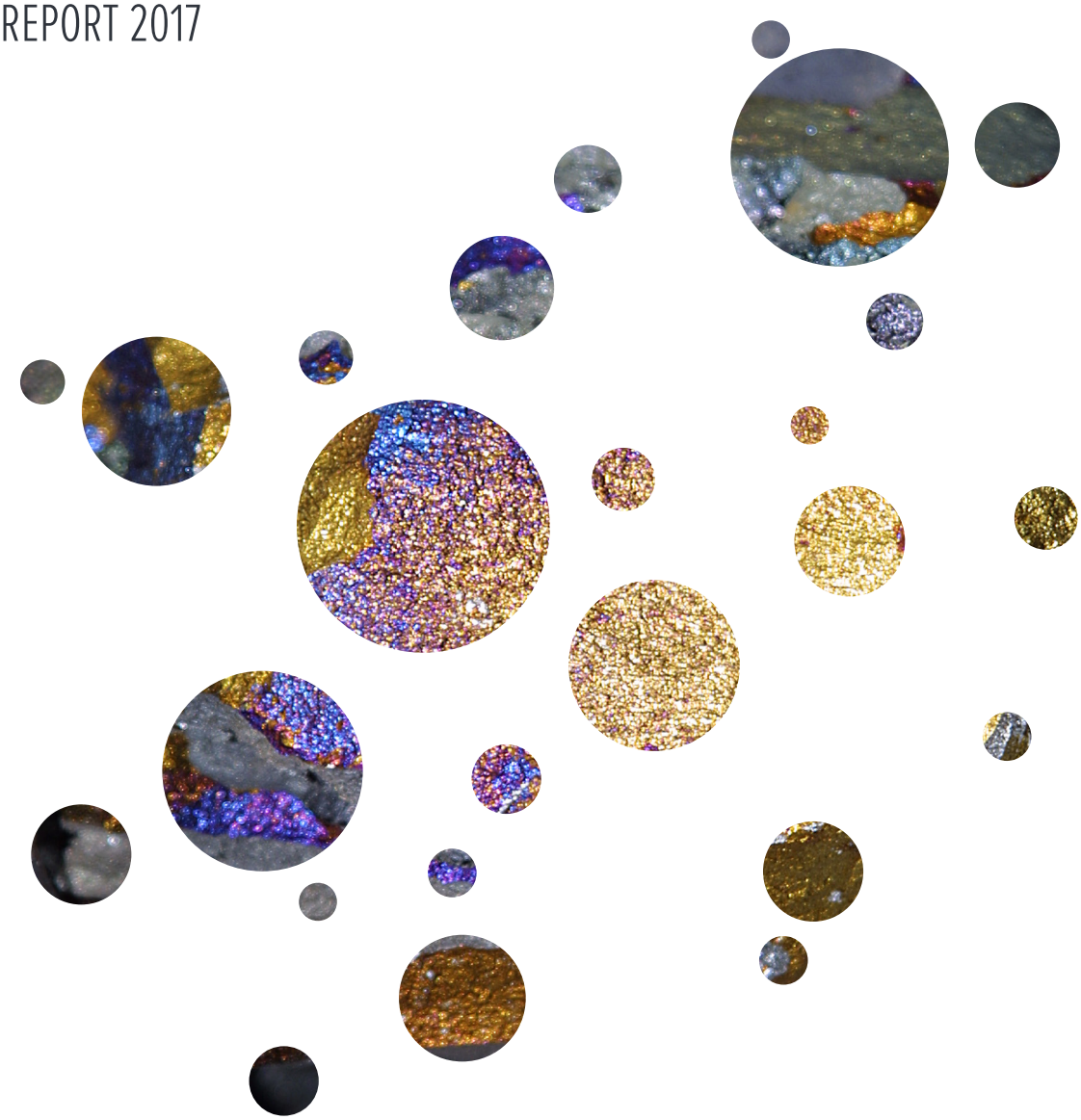
ERAMET NORWAY

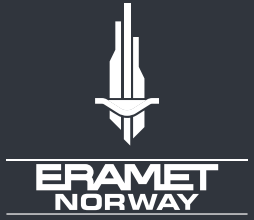
EXPERTISE AND GROWTH

SUSTAINABILITY REPORT 2017



ERAMET NORWAY SUPPLIES MANGANESE ALLOYS TO STEEL MANUFACTURERS ALL OVER THE WORLD

– FOUNDED ON NORWEGIAN INDUSTRIAL TRADITIONS AND THE USE OF SELF-DEVELOPED HIGH TECHNOLOGY



BJØRN KOLBJØRNSEN

CEO of Eramet Norway

WORLD-CLASS EXPERTISE AND A ROADMAP TO GUIDE US

The events of 2017 showed that Eramet Norway is one of the world's most efficient manganese alloy producers.

Favourable market conditions helped a lot, but our ability to evolve, to develop efficient processes and cost-effective operations, is the key to our successful financial performance.
Norway has been a great location for our industry for over a century, and the government has indicated that it wishes us to remain a major player in the future. This gives us the incentive to rise to the challenge of developing and implementing future-oriented climate, energy and environmental technology, in order to meet society's expectations and demands. On page 46, we report on the outcome of our efforts over the past year to create a climate and energy roadmap for our business. The roadmap sets out specific targets and focus areas based on the roadmap for the processing industry published by the Federation of Norwegian Industries (Norsk Industri) in 2016.

RESOURCE-EFFICIENT PRODUCTION OF USEFUL PRODUCTS

As part of the French mining and metallurgy group ERAMET, which has industrial operations on five continents, we recognise the importance of adapting our corporate social responsibility to national and local conditions. It is our fundamental belief that responsible environmental behaviour pays off over time in the form of sustainable financial results. In practice, this means:
– Better utilisation of key raw materials: ore, reducing agents and energy
– Greater stability and efficiency in our production processes
– Increased revenue through circular economy solutions for by-products and waste
– Reduced environmental costs associated with CO2 quotas and other green taxes
– Enhanced reputation as a business, making it easier to recruit skilled, committed employees and to collaborate with external centres of excellence
– Access to support and funding programmes for R&D and capital projects

WORLD LEADER IN REFINED MANGANESE ALLOYS

Eramet Norway has seen considerable improvements in financial performance over recent years. Much of the improvement was due to our success, working in partnership with the group's manganese division, in increasing sales of refined ferromanganese by over 40% in the years following the financial crisis. In 2017 we set production records both for refined ferromanganese and for total sales volume, including standard products. This was the result of several actions:
– We have invested in eliminating bottlenecks and guaranteeing environmental standards.
– We have obtained knowledge through focused R&D work as a basis for improved process control.
– We have worked with our highly skilled process operators and specialists to

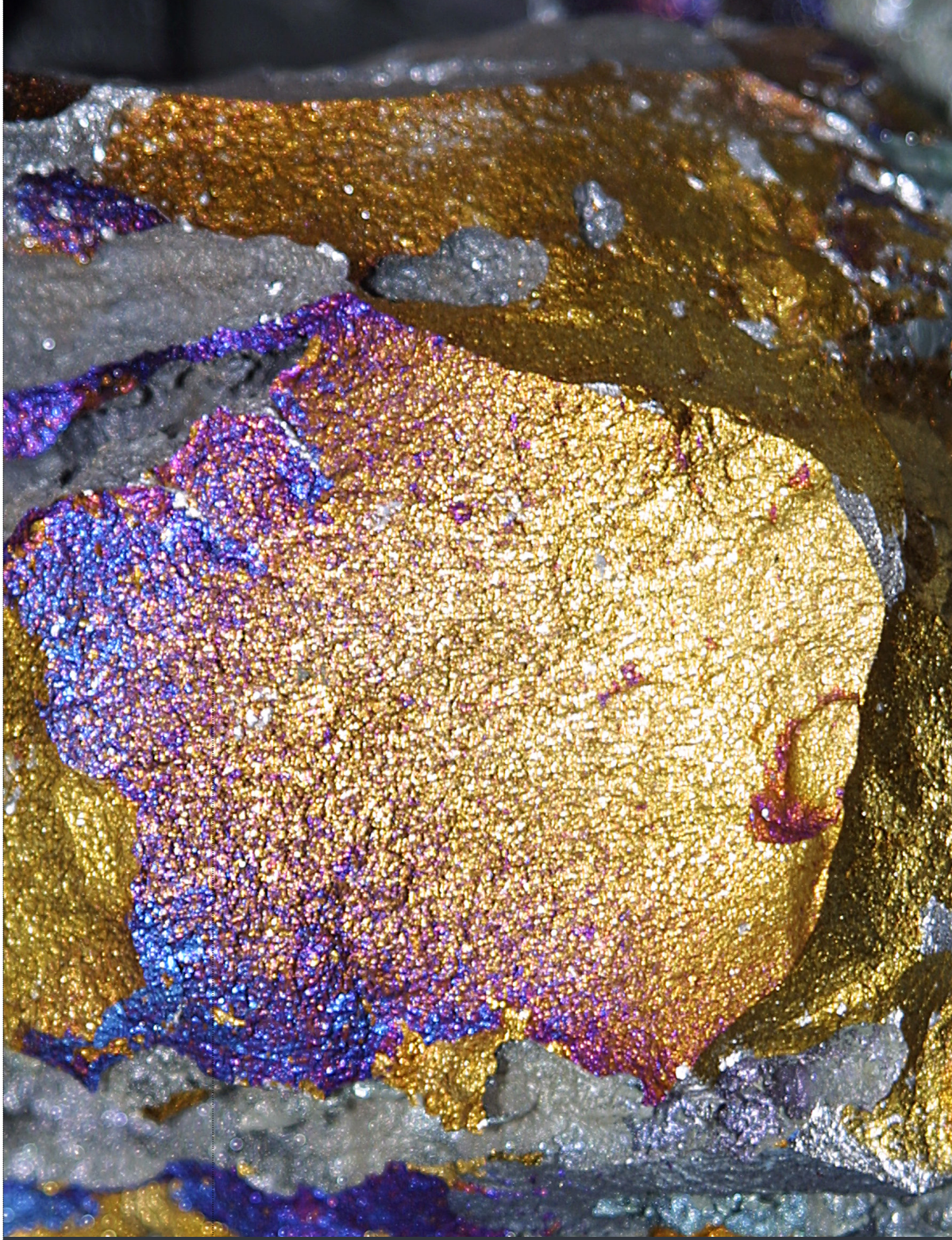
adapt our operations to new technology and changes in process flow.

ACCELERATING CHANGE

While we can look back with satisfaction on developments in recent years, we also realise that we need to step up the pace of change as we embark on our second century of manganese alloy production in Norway. Thanks to generations of skilled employees, we are starting from a strong position.

Our main task in the years ahead is to continue building on our expertise.

We must equip our future process operators, specialists and managers with the knowledge, the skills, the capability and – last but not least – the right attitude to face the challenges and opportunities that lie ahead.



We are one of the world's most sustainable manufacturers of manganese alloys.

Our industry is welcome in Norway, and the incentives offered by government will trigger environmental investment.

A WORLD LEADER IN THE PRODUCTION OF MANGANESE ALLOYS

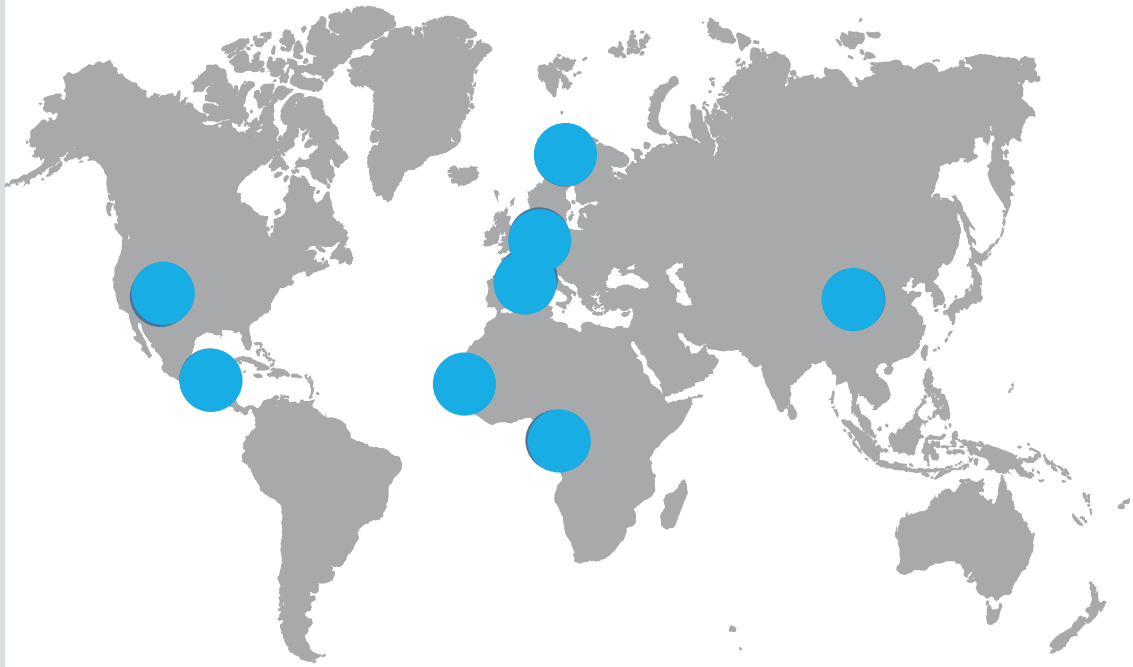
The French industrial group ERAMET is the second-largest producer of manganese ore and the world's largest producer of refined manganese alloys. The company is in the business areas of manganese, nickel and special alloys.

MANGANESE IS A METALLIC ELEMENT BELONGING TO GROUP 7 IN THE PERIODIC TABLE OF ELEMENTS.

Pure manganese is a steel-grey metal. It is hard, but at the same time so brittle that it can be pulverized.
On a worldwide basis, there are large deposits of manganese. In the earth's crust, there are some 900 ppm, making it the second most common metal after iron. It is primarily extracted from the mineral pyrolusite (MnO2), also known as brownstone. More than 80 per cent of occurrences are found in South Africa and Ukraine. Other important deposits are in China, Australia, Brazil, Gabon, India and Mexico. Manganese is also found in the form of nodules on the ocean floor.

MANGANESE IS NECESSARY TO MAKE STEEL DUCTILE AND DURABLE.

For one tonne of steel, about 10 kilograms of manganese alloy is needed. Nearly 90 per cent of the world's total manganese alloy production goes into the production of carbon steel: steel for the construction, energy and transport sectors, and the tool industry, and special steel produced for the aeronautics and aerospace industries.



13 000
employees in ERAMET throughout the world

5 500
employees worldwide in the manganese division

34 BN
NOK revenue in 2017

ERAMET NORWAY – A PART OF THE GROUP´S MANGANESE DIVISION

Eramet Norway is part of ERAMET with processing plants at Sauda, Kvinesdal and Porsgrunn, and an R&D group in Trondheim. The company employs 510 full-time equivalents, and its operations make the ERAMET Group the world's second largest producer of manganese ore and manganese alloys.

FROM SMELTER TO MODERN PROCESSING PLANT

The Norwegian processing plants maintain the traditions and expertise that the ferroalloy industry has built up since industrialization accelerated in Norway in the early 20th century. Today, Eramet Norway supplies manganese alloys to the international steel industry market.

THE WORLDS CLEANEST MANGANESE ALLOY PRODUCTION

Eramet Norway realized early on that environmentally sustainable onshore industry is the way of the future for Norway. Since 2001, when ERAMET acquired the processing plants previously owned by Elkem, about half a billion Norwegian kroner has been spent on developing and adopting green technology. Today, Eramet Norway can proudly boast that we operate the world's cleanest manganese alloy production facilities. ERAMET Norway has a workforce of about 510 employees. It is a part of the ERAMET group, which is the world's second-largest producer of manganese ore.

ALL PRODUCTION ARE EXPORTED

Eramet Norway exports all its production of manganese alloys, primarily to Europe and North America. The processing plants transport 98 per cent of their production by ship and the remaining percentage by road and rail.

ORGANIZATIONAL PHILOSOPHY

The company has a very flat organizational structure built on a strong contribution-based philosophy and the Nordic model of collaboration. ●

World-class Norwegian metallurgical expertise

Metallurgy is a broad field with a long tradition in the ferroalloy industry, in which Norway enjoys high international standing.
Metallurgy is metal technology. The employees working in this specialized field range from apprentices and process operators to doctoral level researchers.
Modern metal technology has become increasingly more sustainable over recent years. ●

International competitiveness

One challenge in operating and developing business in Norway is that, in cooperation with Norwegian authorities, we need to adapt our framework conditions so as to create the basis for strengthening our international competitiveness.

Eramet Norway har god dialog med myndigheter og andre relevante aktører. ●

Everywhere you go you will encounter products that contain manganese alloys.

Eramet Norway supplies the world's steel producers with a complete range of high-quality manganese alloys. In our processing plants in Norway, raw manganese is refined and processed into ferromanganese and silicomanganese. These additive ingredients comprise 1–10 per cent of the composition of steel, graded by quality. Nearly 90 per cent of the world's total manganese alloy production is used to make carbon steel and specialty steels for the construction industry, the aeronautics and aerospace industry, the energy and transport sectors, and the machine tool industry.

The construction market alone accounts for more than half the steel used worldwide.

535 000
tonnes of manganese alloy sold by Eramet Norway in 2017

BUILDING MATERIALS

The biggest outlet for manganese is carbon steel, which is used to make the essential parts of all modern buildings. Concrete reinforcing rods contain manganese which makes them stronger and stiffer. High speed steel saws are used extensively to cut structure parts on construction sites. On average around the world, it takes 7 kilos of pure manganese or 10 kilos of manganese alloys to make 1 ton of steel.

BATTERIES

Manganese is used to make alkaline batteries, for which it is the main raw material. It is also a key component in cathodes for lithium-ion batteries.

ENERGY SECTOR

High-grade steel is a critical factor in the global transition to renewable and more efficient energy sources over the coming decades.

TRANSPORT

Manganese steels are valed for their great wear and distortion resistance. They are used to make a range of rail infrastructure parts as they can withstand the weight of trains and keep tracks straight. Vehicle manufacturers use them for the same properties. In this area, some high-tech applications use closely alloyed manganese steels.

AVIATION

These steels and superalloys are used to produce an aircraft's vital parts, delivering the essential qua-lities of strength and safety. In the extreme heat and corrosion of engines, for example, safety is paramount. Landing gears, comprising many high-performance steel, aluminium and titanium parts, are subject to severe mechanical constraints.

When it comes to advanced technology, few metal producers can match Eramet Norway.

PRODUCTION OF MANGANESE ALLOYS AND CONSUMPTION OF RAW MATERIALS

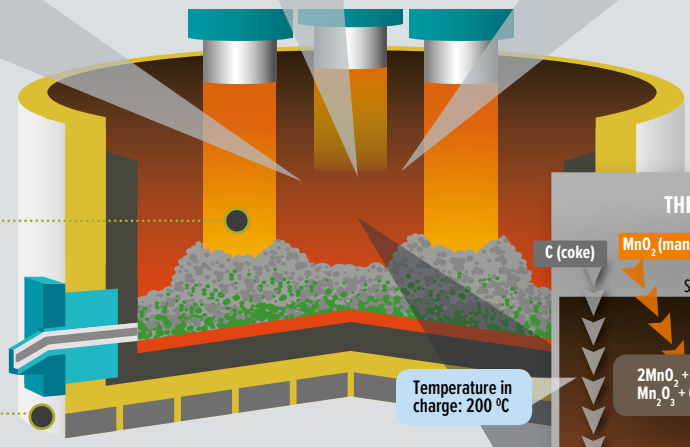
ORE
Maganese source

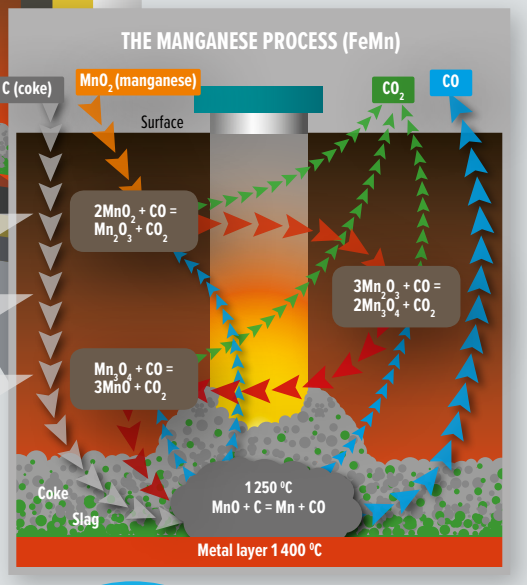
COKE
Carbon as a reducing agent

SLAGGING
Gives slag better viscosity (fluidity) and enables correct chemical composition for obtaining optimal manganese reduction

ELECTRODES
Supplies the process with electrical energy – equivalent to the consumption of 20,000 households

FURNACE
Able to withstand extremely high temperatures – more than more than 2,000°C





937 000
tonnes of manganese ore consumed in 2017

239 000
tonnes of metallurgical coke consumed in 2017

95 000
tonnes of quartz consumed in 2017

WORLD-CLASS TECHNOLOGY

Eramet Norway has a century of experience in manufacturing manganese alloys. This knowledge base, developed over generations, is Eramet Norway's most important resource and asset. This expertise has also made the company a leader in smelting and refining manganese alloys.

Today, the refining process is an advanced, highly technological process that few other countries in the world are able to emulate. From the time an optimal mix of ore and coke is blended and sent to the furnace, and until the crucial refining process has been completed, precision and experience are essential. With the aid of an advanced control system, every stage of production is monitored in detail, and the laboratories take samples at regular intervals to test quality.

13 000
tonnes of electrode paste consumed in 2017

660
tonnes of natural gas and propane consumed in 2017

2.0 TWh
of electrical energy and auxiliary power consumed in 2017

Raw materials from our own mine

Eramet uses significant quantities of raw materials in its production every year. These raw materials come from both foreign and domestic suppliers, and they are mainly:

- Manganese ore, with Eramet having access to its own mine in Gabon via its part-owned company, Comilog
- Metallurgical coke
- Quartz and limestone

Other factor inputs

Other important factor inputs are electrode paste and metallic silicon sources. During the smelting process, a number of internal products are produced and consumed. They are transferred as required to other parts of the same plant and between the three processing facilities.

Energy consumption

The combined electrical energy consumed in the smelting processes, including auxiliary power, was about 2.0 TWh in 2017. The required amount of natural gas and propane used as thermal energy sources amounted to almost 660 tonnes. Eramet Norway is also one of the country's largest consumers of industrial gases, particularly liquid oxygen, in production processes.

Eramet Norway is founded on longstanding industrial traditions. The three Norwegian processing plants are located between the fjords and mountains of Rogaland, Vest-Agder and Telemark.

ERAMET NORWAY SAUDA

Sauda, in the northeast part of Rogaland county, is a community of 5,000 inhabitants. The local rivers were harnessed for hydroelectric power generation in the early 20th century, paving the way for industrialization in Sauda.
Eramet Norway's processing plant in Sauda employs about 163 people and, with its two 40 MW furnaces, is the largest ferromanganese producer in northern Europe.
Production has more than doubled since the 1960s, and over 75 per cent of the plant's revenue is from refined products.
Annual power consumption totals 730 GWh when the plant is operating at full capacity. Measured in tonnes produced, Sauda is the largest plant in the Eramet Norway family.
Sauda has the highest output of refined ferromanganese alloys, processing about 60 percent of the manganese ore imported by Eramet Norway. Eramet Norway Sauda is a driving force in the region's socioeconomic development and takes its corporate social responsibility seriously, benefiting both the company and our stakeholders.

Ownership interest in a quartz quarry operator, Georg Tveit AS.

R&D GROUP IN TRONDHEIM

Eramet Norway's development group in Trondheim consists of three researchers with access to the facilities and expertise of NTNU and SINTEF. Working as a team, they are all acknowledged experts in applied research who continuously pursue enhanced understanding and greater insight. The development group supports the processing plants at Kvinesdal, Sauda and Porsgrunn, and contributes to innovation and knowledge dissemination within Eramet Norway.

ERAMET NORWAY PORSGRUNN

Porsgrunn is a city of 35,000 residents in Telemark county. As the successor to a plant first established in 1913, Eramet Norway Porsgrunn is a modern, high-technology business with long and proud traditions. Average seniority among the workforce is 23 years, and it is not uncommon to encounter second- and third-generation employees manning the smelting furnaces.

The plant is considered an attractive workplace locally and currently employs 152 people. Equipped with two smelting furnaces and a refinery facility, the plant produces 65,000 tonnes of silicomanganese and 115,000 tonnes of refined ferromanganese annually. The plant consumes 570 GWh of electricity annually, from which it recovers almost 200 GWh of thermal energy by supplying carbon monoxide gas to Yara's ammonia factory at Herøya.

ERAMET NORWAY KVINESDAL

Established in 1974, Eramet Norway Kvinesdal is centrally located in the Lister region. Kvinesdal is a community of 5,800 residents, 195 of whom work at Eramet Norway in 2017. The modern, highly versatile processing plant is a key player in the local community and an undisputed leader in energy recycling, flexibility, adherence to emissions requirements and, not least, customer satisfaction.

The plant consumes 750 GWh of electrical energy annually and is strongly committed to energy recycling. As long ago as 1981, a thermal power plant was built, which now supplies nearly 90 GWh annually to the grid. Wastewater is reused by the plant itself and by external customers, including a turbot farm producing 250 tonnes of fish annually. A district heating plant, built in 2007, supplies hot water to five external customers for heating off-site workshops.

MOVING RAW MATERIALS BY SEA

Eramet Norway's three processing plants are situated on the coast, and most of our goods are transported by sea. Every year 18 cargo ships arrive laden with manganese ore from Africa, and internal shipments between plants also go by sea.

1.8M
tonnes of raw materials consumed in 2017

930
vessel calls in 2017

Our plants consumed 1,769,632 tonnes of raw materials in 2017. Less than 1% of these raw materials arrived by road.
Most raw materials arrive at the plants by sea. We use ships more than any other transport mode. Our charterers, purchasers and brokers make sure we always obtain competitive shipping rates and quality service under the terms of our contracts.

INTERNAL CARGO PROCESSES

Materials are also moved between plants. In 2017, we transported 500,000 tonnes of semi-finished goods from one plant to another and sold over 535,000 tonnes of finished goods. The reason we move such large quantities between plants is that, for instance, slag produced at Sauda can be used as raw material at Kvinesdal.
Sold product is transported mainly by ship and/or in containers.

TO AND FROM ALL PARTS OF THE WORLD

Manganese ore from Gabon accounts for the largest share of raw materials. In 2017, 18 cargo vessels, each carrying 50,000 tonnes of ore, sailed from Gabon and South Africa to Kvinesdal and Sauda. En route, ore is transferred to the Porsgrunn plant using smaller coastal vessels. Trans-shipment takes place in the Åmøyfjord off Stavanger and/or at the docks in Kvinesdal.

Eramet Norway also purchases almost 200,000 tonnes annually of quartz from Kragerø, limestone from Verdal and slag from Tyssedal. Coal tar pitch for electrode paste is obtained from various locations including Kristiansand.
Reducing agents such as coke are another important category of raw materials. We consume about 250,000 tonnes annually, sourced from Russia, China, Poland, Colombia and other countries.

Finished goods from our Norwegian plants are exported to steelworks in

Europe, the United States, Russia, Asia, Africa and South America.

Every year, 930 vessels call at Eramet Norway's three harbours, and our plants process over 3 million tonnes of materials.

TRUDE SUNDSET

CEO of Gassnova

CCS LAYING FOUNDATIONS OF FUTURE ECONOMIC GROWTH

ERAMET is involved in a CLIMIT-funded project under the umbrella of the Eyde Cluster to study carbon capture and storage (CCS) at the Sauda and Kvinesdal plants. The project is an important first step towards sustainable management of CO_2 emissions.

Green thinking is no longer just about the environment, but about creating a sustainable basis for future economic growth. According to both the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC), there are three main means of halting climate change and achieving the targets set by the Paris agreement: energy efficiency, renewables and large-scale CCS implementation.

Nowhere is CCS more essential than in industry, which generates 25% of global CO_2 emissions.

The roadmap for the processing industry (Norsk Industri, 2016) identifies CCS as a key tool for reducing the industry's carbon emissions. Many sectors have no alternative to CCS if they are to cut emissions, since a large proportion of industrial emissions are directly attributable to the production process.

CCS VALUE CHAIN OPENS DOORS

Even with solar panels on every factory roof, industrial processes will still produce large CO_2 emissions. If these are not reduced, it will not be possible to meet the Paris targets.

For this reason, Norwegian industry is looking to CCS. Access to CCS infrastructure will allow industry to invest with confidence, since increased output will no longer mean higher emissions. A complete CCS value chain also opens the doors to new industries and more jobs. Hydrogen is an exciting example. If CCS infrastructure is available, we can produce zero-emission hydrogen from natural gas. Equinor (formerly Statoil) and several other companies are currently investigating potential business opportunities for turning natural gas into a clean energy source.

Norway has been capturing and storing CO_2 offshore since 1996, so we have extensive experience of CCS as an effective, safe alternative to CO_2 removal.

25%
of global CO_2 emissions come from industry

SUPPORTING INDUSTRY FROM RESEARCH TO IMPLEMENTATION

Gassnova is a Norwegian government-owned company focused on carbon capture, transport and storage.
Our mission is to help create a green economy. By capturing CO_2 before it enters the atmosphere and transporting it to a secure storage site, industry can increase production while reducing carbon emissions almost to zero.

Gassnova is involved in three equally important – and mutually dependent – activities that can help industry in its efforts to become carbon-neutral:

1) Research into CCS technology through the CLIMIT programme. CLIMIT has recently awarded funding for a project under the umbrella of the Eyde Cluster to study CCS options for Eramet's processing plants at Sauda and Kvinesdal.

2) Testing of carbon capture technology at the world's largest testing centre, Teknologisenter Mongstad (TCM), where technology providers can test their solutions on an industrial scale prior to implementation.

3) Development of full-scale infrastructure for capturing, transporting and storing CO_2.

We need to pursue all these activities if we are to achieve the large-scale CCS implementation we need in future.

NORWAY'S FULL-SCALE CCS PROJECT

We are currently working on an integrated value chain for carbon capture, transport and storage. Instead of focusing on capturing CO_2 emissions from a single location, such as Sleipner, we are developing a flexible infrastructure.
In the first instance, three industrial producers are planning to connect to the system: the Norcem cement works at Brevik in Telemark, the Yara fertiliser plant at Herøya in Telemark and the Fortum recycling facility at Klemetsrud in Oslo.
Between them, they emit 1.5 million tonnes of CO_2 annually – roughly equivalent to 20% of the fossil-fuelled cars in Norway.
While these three businesses work on developing carbon capture solutions, Equinor, Shell and Total are collaborating on a CO_2 storage facility in the North Sea. We are also devising a flexible maritime transport system.

Continued overleaf

CO_2 captured at industrial sites will be transported by ship to an intermediate storage facility before injection into the permanent carbon store. Once this infrastructure is in place, it will be much easier for other large emitters to connect to the system.
A number of industrial producers from Norway and beyond are already looking into connecting.
Preem, Sweden's largest oil refinery, recently announced that it had obtained funding for a CCS pilot study at its Lysekil plant. Sweden has no CO_2 storage facilities of its own, and Preem's goal is to create a full-scale carbon capture system that can be connected to Norway's planned storage infrastructure.

BENEFITS OF A COMPLETE CCS VALUE CHAIN

Gassnova's task is to provide the Norwegian parliament with a sound basis for its decision this summer on further progress and subsequent capital spending decisions. We are working to reduce the risks and costs. Gassnova is also seeking to highlight the value created, with climate benefits from day one. We can show the world that it is feasible and safe. Existing industries can operate emission-free and gain new markets. We can convert existing industrial plants to serve a new sector, and we can create a whole new industry where Norway is in the driving seat.
We already know that CCS technology works and that CO_2 can be stored safely, but we need to demonstrate a complete value chain for industrial emissions by devising a flexible transport and storage solution. If our demonstration project in Norway is a success, we can change the world's perception of CCS so that others see it as a solution to be emulated. The lessons we learn will help reduce costs and improve efficiency in future CCS value chains. Major capital expenditure will be needed to make the full CCS value chain a reality in Norway. But the scenarios outlined by the IPCC show that achieving climate targets by means other than CCS is likely to cost more than twice as much.

Although much work is under way, and we have made progress, the world is still falling far short of the Paris targets.

Getting CCS on track may be the most important challenge facing us in the next few years.

CCS is not just about avoiding destructive climate change. It is an investment in the future: in jobs, new industries and future growth in Norway, Europe and the wider world.

According to the IEA and the IPCC, there are three main solutions for halting climate change and achieving the Paris targets:

1. Energy efficiency
2. Renewables
3. CCS implementation

The Paris agreement is an international agreement signed at the Paris climate summit in December 2015. It includes measures for reducing greenhouse gas emissions, adopting climate-friendly technologies and supporting environmental action by developing countries.

Objectives of the Paris agreement:
- To keep the rise in global average temperatures from pre-industrial levels well below 2°C and if possible to no more than 1.5°C
- To improve our ability to adapt to climate change, and to promote climate resilience and low-emission development in a way that does not threaten food production
- To make finance flows consistent with climate-resilient, low-emission development

REDUCING EMISSIONS THROUGH SMART USE OF FURNACE GAS

There is a unique story behind the working relationship between the manganese and ammonia producers at Herøya in Porsgrunn. For almost 50 years, Eramet Norway has been supplying furnace gas to Yara's ammonia plant.

Transferring furnace gas from Eramet Norway to Yara as an energy source eliminates the need for flaring and reduces both companies' carbon emissions.

Gas from the two furnaces at Porsgrunn is purified in the mercury removal unit (MRU), to remove dust and metals, before being transferred to Yara via a pipeline. A huge compressor feeds the gas into the chemical plant, reducing Yara's reliance on virgin energy sources. Over the years, this working relationship has reduced the combined carbon emissions of the two businesses.

SETBACKS IN 2015/16

When the plant was operating at high capacity in 2013/14, sales of furnace gas to Yara provided a substantial revenue stream. However, this revenue fell by about half in 2015, owing mainly to the drop in oil prices. Furnace gas sales took a further hit in 2016 because of a scheduled maintenance shutdown at Yara.

POWER OUTAGE HAS KNOCK-ON EFFECTS

Sales of furnace gas were back on budget until 24 April 2017, when a power outage in Skagerak Energi's regional grid led to a fire in the compressor hall at Yara, destroying equipment and shutting down production. We were unable to resume furnace gas deliveries until 3 October 2017.

HIGHER CARBON EMISSIONS

Yara has identified and rectified the underlying causes, but a leak in the HP steam system at NII Eramet resulted in a further unscheduled shutdown of furnace gas deliveries for two periods of 10 days each. Consequently, large amounts of furnace gas from the MRU had to be flared, causing a significant increase in Eramet Norway Porsgrunn's carbon emissions for 2017.

GREATER STABILITY IN 2018

In 2018 to date, furnace gas deliveries have been running at close to maximum capacity again. Yara is conducting a feasibility study to identify possible improvements with regard to flow fluctuations and to increase consumption of furnace gas. Yara is also initiating a pilot project to examine the possibility of eliminating and reducing some of the bottlenecks in the current transmission system, in order to avoid flaring. Increased transformer capacity was installed in both furnaces at Porsgrunn in 2016/17, and naturally we are interested in putting the increased volumes of furnace gas to good use.

This project is likely to require a new buffer tank, a higher-capacity compressor and a transmission fan or blower. Eramet and Yara are planning to conduct new capacity tests to identify the potential gains.

DEVELOPING BIOCARBON FOR THE Mn PRODUCTION OF THE FUTURE

Eramet Norway has identified the replacement of fossil carbon material with biocarbon as one of the most promising technologies for a major reduction of CO_2 emissions from the smelting process.

From 2014 to 2017, Eramet Norway was involved in the now completed Biocarb+ project. In this project, the company developed a fundamental knowledge of the entire value chain around the use of biomass in metallurgical applications. This knowledge forms an important foundation for ongoing research into biocarbon.

INCREASING BIOCARBON EXPERTISE

Commercially available biocarbon materials present a number of challenges that could limit their use in Eramet Norway's closed furnaces. In order to be able to replace large quantities of today's fossil carbon materials with biocarbon, Eramet Norway is actively participating in a number of research and development projects aimed at increasing knowledge, as well as developing biocarbon materials suitable for Mn production.

EYDE BIOCARBON

At the initiative of AT Skog, the Eyde Biocarbon project has run from 2014 to 2018 with the goal of establishing production of environmentally friendly biocarbon for the metallurgical industry based on Norwegian forest products. AT Skog is an organisation jointly owned by most of the family-owned forestry businesses in Agder and Telemark.

Biocarbon materials have been produced at pilot scale with realistic process conditions. The research at Eramet Norway in 2018 involves verifying the suitability of this biocarbon for manganese production.

The project is managed by Teknova, and the processing industry partners are Eramet Norway, Alcoa, Elkem and Saint-Gobain.

PYROGASS

The four-year PyroGass innovation project was started in 2017 by Norske Skog Saugbrugs. The objective is to develop new technology for combined production of biogas fuel and biocarbon. Through the utilisation of residual raw materials from paper production, the intention is to develop a combined pyrolysis and agglomeration process for the production of biocarbon which will specifically replace fossil carbon material in the manganese industry. The project is being conducted in partnership with RISE PFI in Trondheim, the University of South-Eastern Norway in Porsgrunn (USN) and Cambi.

NEW SINTEF PROJECT

In 2018 a major new industrial expertise project titled "Reduced CO2 Emissions in Metal Production", under the management of SINTEF, was approved by the Research Council of Norway.

The project's objective is to develop a basis for reducing the effect on climate of the production of Si, FeSi, manganese alloys and TiO_2 slag so as to achieve the targets outlined in the roadmap for the processing industry relating to increased value creation, 30% CO_2 reduction by 2030, and zero CO_2 emissions by 2050.

In the project, the Norwegian metallurgical industry will have access to a biocarbon test centre where the metallurgical properties of carbon materials can be studied in detail from submicroscopic up to pilot scale. The project will run from mid-2018 to mid-2022. In addition to the institutional partners (SINTEF, NTNU and CICERO), industrial partners from the Norwegian Ferroalloy Producers Research Association (Eramet Norway, Ferroglobe, Elkem, Wacker and Finnfjord) and TiZir will participate in the project.

SINTEF

SINTEF is a broad and multidisciplinary research organisation with international core expertise in technology, science, medicine and social science. SINTEF conducts contract research as an R&D partner for industry and administration and is amongst the four biggest contract research organisations in Europe.

NTNU

NTNU (Norges teknisk naturvitenskaplige universitet) is the country's biggest and leading supplier of engineers, covering areas of technology that range from nanotechnology and IT, to petroleum technology and ship design.
NTNU, which has its own research environments, works together with some of the country's most important technological and industrial companies.

TEKNOVA

Teknova AS is a technology and science research institute. Its operations are aimed at contract research, technological development and innovation.
The institute aims to develop knowledge and technology, and to create value for its users, for society and for its owners.
Teknova aims to create proximity and cooperation between the University of Agder, Agder Research and trade and industry in the Sørland region.
Due to the international nature of its research activities, Teknova will develop a broad, international field of activity and international collaboration relationships

GREENER PRODUCTION BASED ON RESEARCH

The R&D department at Eramet Norway works with several prominent research bodies, including ERAMET Research within the group and external organisations such as SINTEF and NTNU in Trondheim, Teknova, Tel-Tek, FFF, Elkem Technology and PFI.

Eramet Norway's R&D programme involves long-term partnerships with:

- ERAMET Research, the ERAMET group's research centre
- The Norwegian Ferroalloy Producers Research Association (FFF) since the 1990s
- Eight-year research projects funded by the Research Council of Norway (SFI Metal Production on process and environment, FME HighEFF on energy efficiency)

A number of other projects partly funded by the Research Council of Norway, the EU, ENOVA and Innovation Norway contribute to Eramet Norway's R&D activities.

In 2018 the focus will be on the following aspects of sustainable development:

Efficient resource use:

Eyde Waste to Value

- Aimed at reducing landfill waste and making greater use of by-products (Eyde cluster)

EU Project GO-4-0

- Coordinated by ERAMET Research

Diffuse emissions:

DeMaskus

- FFF-sponsored project studying the mechanisms behind dust formation in Mn alloy production, with the aim of improving the working environment

GassFerroSil

- Aimed at using natural gas in Mn alloy production as a CO_2-reducing measure

SCORE

- Aimed at the innovative use of flue gas to reduce emissions and increase energy utilisation

Energy:

NewERA

The R&D department has also contributed to the critically important NewERA project, which is part-funded by ENOVA. The aim of NewERA is to develop and implement technologies for reducing CO2 emissions and achieving more efficient energy utilisation. (CAU/ODSU part-funded by Innovation Norway and in partnership with ERAMET Ingenierie)

Greenhouse gas emission reduction:

Biocarb+, Pyrogass

- Aimed at developing a biocarbon-based process suited to Mn alloy production. Eyde Biocarbon (Eyde cluster) and Pyrogass (in partnership with PFI, Paper and Fibre Research Institute)

KPN CO_2 reduction in the processing industry

FFF

The Norwegian Ferroalloy Producers Research Association

This organisation was founded by the Norwegian ferroalloy industry in order to collaborate on research in ferroalloy processes and products.
The aim of the FFF is to maintain the position of the Norwegian ferroalloy industry at the forefront in ferroalloy production and of electrometallurgical technology.
Its biggest member companies are Eramet Norway and Elkem, and together they contribute something like 80 per cent of the organisation's subscription funding, with each accounting for almost equal parts.
At the same time, the Norwegian Ferroalloy Producers Research Association (FFF) is the most important arena for joint research within the industry. In particular, Eramet Norway is a member of the Eyde cluster, where R&D occupies a central position.

The Norwegian processing industry is highly energy-efficient and uses clean, renewable hydroelectric power, making it a world leader in sustainability.

Extractor systems and oxy-fuel burners reduce diffuse emissions and improve the working environment.

OPTIMAL VENTING DESIGN YIELDS ENVIRONMENTAL BENEFITS

All Eramet Norway processing plants have made significant efforts towards the goal of reducing diffuse emissions generated by various metallurgical processes.

The collaboration between the plants and the R&D department at Eramet Norway has always been a close and satisfactory one with respect to research and development projects, including those on environment-related subjects. The results of these projects and the efforts made at plant level have improved all environment-related indices throughout the Eramet Norway business. The company has now built up invaluable expertise in finding good industrial solutions to today's environmental problems.

SYSTEMATIC APPROACH AS A METHOD

Effective collection of smoke and dust from various metallurgical processes (furnace tapping, metal and slag casting, metal refining, filling/pouring of metal into the refinery converter, ladle transport, etc) has always been a major challenge in the ferroalloy industry. Many businesses struggle with inadequate solutions for capturing emissions. Eramet Norway has now adopted a systematic approach to optimal design of venting systems and extractor points.

	Stages	Tasks/initiatives	Expected results
1	Initial investigations	Shop floor observations, measurements, and discussions with process operators	The main cause of the problem is recognised Emission sources are characterised
2	Definition of success criteria for the design	Establishment of various operational objectives for the design	Expectations for the design are defined
3	Theoretical studies	Assessment of various aspects of the process relating to diffuse emissions Development and use of various models	Controlling conditions for the process are simulated Principal parameters are identified Various design ideas are collected
4	Design and modifications	Simulation of various designs using CFD techniques	Different designs are evaluated and the optimal design is selected
5	Completion of the design	Assessment of all practical and operational details of the recommended design experienced plant staff	Final design
6	Implementation of the design at the plant	Construction and installation of the design and fine tuning as needed	Effective performance of the design in operation exactly as simulated by the CFD model
7	Evaluation of the design in operation	Shop floor observations, measurements, and discussions with process operators	Evaluation of the entire project Documentation of the work

Evaluation of the new tapping venting system shows that the new design performs much better at capturing diffuse emissions inside the ENS12 tapping zone.

Case study: Furnace 12 at Eramet Norway Sauda (ENS12)

Staff at the Sauda plant reported that the tapping venting system for ENS12 was not functioning as expected and was allowing a significant amount of dust to escape into the furnace hall during tapping operations. Eramet Norway Sauda and the R&D department embarked on a joint project aimed at solving the problem. The results of the initial investigations showed that unsatisfactory design of the venting unit was the main reason for poor dust capture in the ENS12 tapping zone. Following the initial investigation and discussions among the project team, it was concluded that a new design for the tapping venting system should be drawn up. It was also decided that the new venting system should be capable of capturing all the dust formed in the metal and slag ladles during tapping.

Various design ideas were sketched and simulated with the aid of a CFD modelling tool. The results of this work led to the optimal design being identified, constructed in advance, and subsequently installed on the furnace in the course of a single operational shutdown.

MAKING PROGRESS ON NEW EMISSION PERMITS

Four years of work to obtain new emission permits for the Porsgrunn and Kvinesdal plants are nearing completion.

In May 2014 the Norwegian Environment Agency (Miljødirektoratet) announced a review of emission permits for all manganese plants in Norway. There were several reasons for the review. Much has changed with regard to emissions in general: new emissions treatment technology has been developed, and new rules and regulations introduced. The existing permits also varied greatly in terms of structure and limits. New emission limits based on a uniform framework were to be brought in.

The objective of the new emission permits was not to impose the same limits on all processing plants, but to set the new limits using the same framework.

APPEAL LODGED WITH MINISTRY

Four years on, Eramet's Porsgrunn and Kvinesdal plants have been granted new emission permits effective 1 May 2017. Owing to capacity shortages at Miljødirektoratet, the emission permit for the Sauda plant is still being worked on but is expected to be granted by year-end.

Eramet Norway and Miljødirektoratet were unable to reach complete agreement on the emission permits for Porsgrunn and Kvinesdal. We have therefore lodged an appeal with the Ministry of Climate and Environment and have a meeting scheduled with the ministry in mid-April 2018. The main reason for our appeal is that the limits set for dust emissions are far below the established European limits based on the use of best available technology. Miljødirektoratet also failed to make the necessary distinction between normal and abnormal operation in the processing industry when granting the permits.

NEW PERMITS REFLECT A GREENER FOCUS

Regardless of the appeal outcome, the new emission permits show a much sharper focus on the environment. We are seeing emission limits becoming steadily stricter, more substances subject to regulation, and tighter requirements on monitoring and measurement. This reflects general attitudes to the environment in society at large. We all need and expect to inhabit an environment that will not adversely affect our life and health. Eramet's processing businesses must live up to these standards if we are to continue supplying our products.

CAN ERAMET NORWAY MEET THE NEW REQUIREMENTS?

In fact, we are not in a bad position in relation to the new requirements. On the whole, we are compliant, but we need to improve on a few points: in particular, diffuse dust emissions, emissions via surface water from our sites, and certain component emissions from our treatment plants. As we focus on continuously improving monitoring of our processing and treatment plants, we expect to achieve full compliance with the new requirements.

We need to work on technical improvements as well as constantly raising awareness of our environmental impact throughout the organisation. ●

BY
HÅKON SKISTAD

Håkon Skistad has worked at SINTEF on ventilation of smelters and other industrial operations since 1976. Within the Norwegian processing industry he is considered an authority on mapping and measuring dust emissions. Mr Skistad is acting as a consultant to Eramet Norway on mapping diffuse emissions from the Porsgrunn and Kvinesdal plants in response to the issues raised by the Norwegian Environment Agency over new emission permits. Similar work will be undertaken at the Sauda plant when it is granted its new emission permit.

MEASURING OF DIFFUSE EMISSIONS TO AIR

Diffuse emissions to air consist of pollutants that escape from processing facilities through roof louvres and structural gaps, and from dust stirred up outdoors, for example in the handling of unconsolidated materials.

Diffuse emissions can constitute amounts larger than the total of all the controlled emissions from a smelter such as emissions through smokestacks. It is therefore important to quantify these emissions, not only because the authorities require it, but also because it is important to know how large the emissions from the various sources are, so that the work of reducing the emission sources can be prioritised.

HOW TO MEASURE DIFFUSE EMISSIONS FROM FURNACE HALLS?

There are no standard meas-

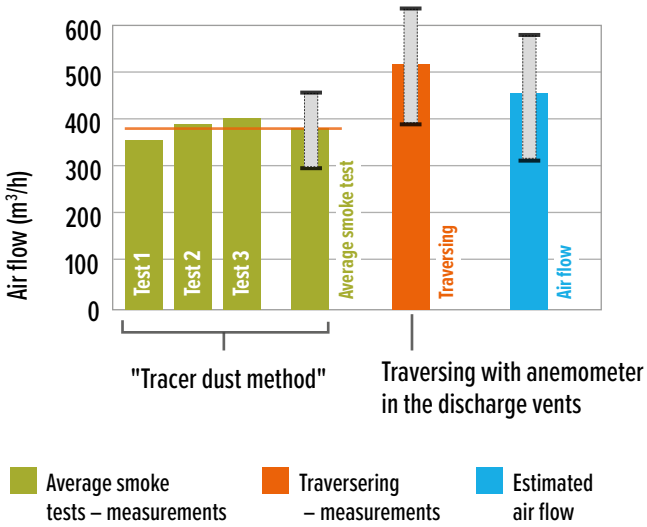
uring techniques suitable for measuring diffuse emissions, but there are three methods that may be used to locate them:

The traverse method is the one that comes closest to the method used for standard measurements. It is based on the concept that openings where smoke and gases escape are traversed by instruments measuring airflow and concentration of pollutants. We use this method where possible, but it is not suitable in most cases.

The tracer dust method is based on the concept that a furnace hall is allowed to fill up with smoke before we measure how rapidly the smoke disappears when the smoke supply to the space is cut off. We obtained the idea from tracer gas measurements, a recognised method for measuring air replacement in a ventilated space. In smelter operations, the space volume is so large that excessively large gas flows would be required to carry out tracer gas measurements. However, what we have enough of is smoke – all we have to do is to shut off the discharge vent from the tapping or casting processes, and the furnace hall fills up with smoke. The hot smoke will rise and fill

Continued overleaf

Emissions are calculated as the air volume multiplied by the concentration of pollutants in the emitted air.



the upper portion of the space, while the lower portion of the furnace hall will be occupied by a layer of colder air with less smoke. During the measurement process, we use video cameras to document how large a portion of the space is filled with smoke and a dust logger to record how quickly the smoke thins out in the hall.

Source summation means that one tries to find out how large an emission is escaping from each individual source in the furnace hall.

EMISSIONS VARY WITH TIME

Emissions are calculated as volumetric air flow times the concentration of pollutants in the emission air. The volumetric air flow both varies over the length and width of the roof vents and varies with time depending on the wind direction and speed. It also varies with heat output in the furnace hall. In order to obtain the best possible picture of air flows, we make a traverse of the discharge vents over the course of several hours before setting up one or two flow meters to record air flow speed continuously over a period of several weeks or months. In this way, we obtain a measurement value of the air flow during the traverse period, and how the air flow varies over time.

The concentration of pollutants in the emission air varies also with time. The most important factor in this variation is the level of activity in the furnace hall.

To measure the concentration in the emission air, we must measure it over several days. We measure the accumulation of pollutants on a filter over a period of six to eight hours and repeat these measurements several times until we arrive at a value for the average concentration. This average concentration covers all the work operations taking place in the furnace hall.

In addition to measuring averages, we use optical meters to record the dust concentration continuously over a working day.

We use this measurement to determine which processes result in the greatest emissions, so that we can have an idea of what should be prioritised in our efforts to reduce emissions.

MEASUREMENT ERROR

All measurement techniques have a margin of error. At present, we know very

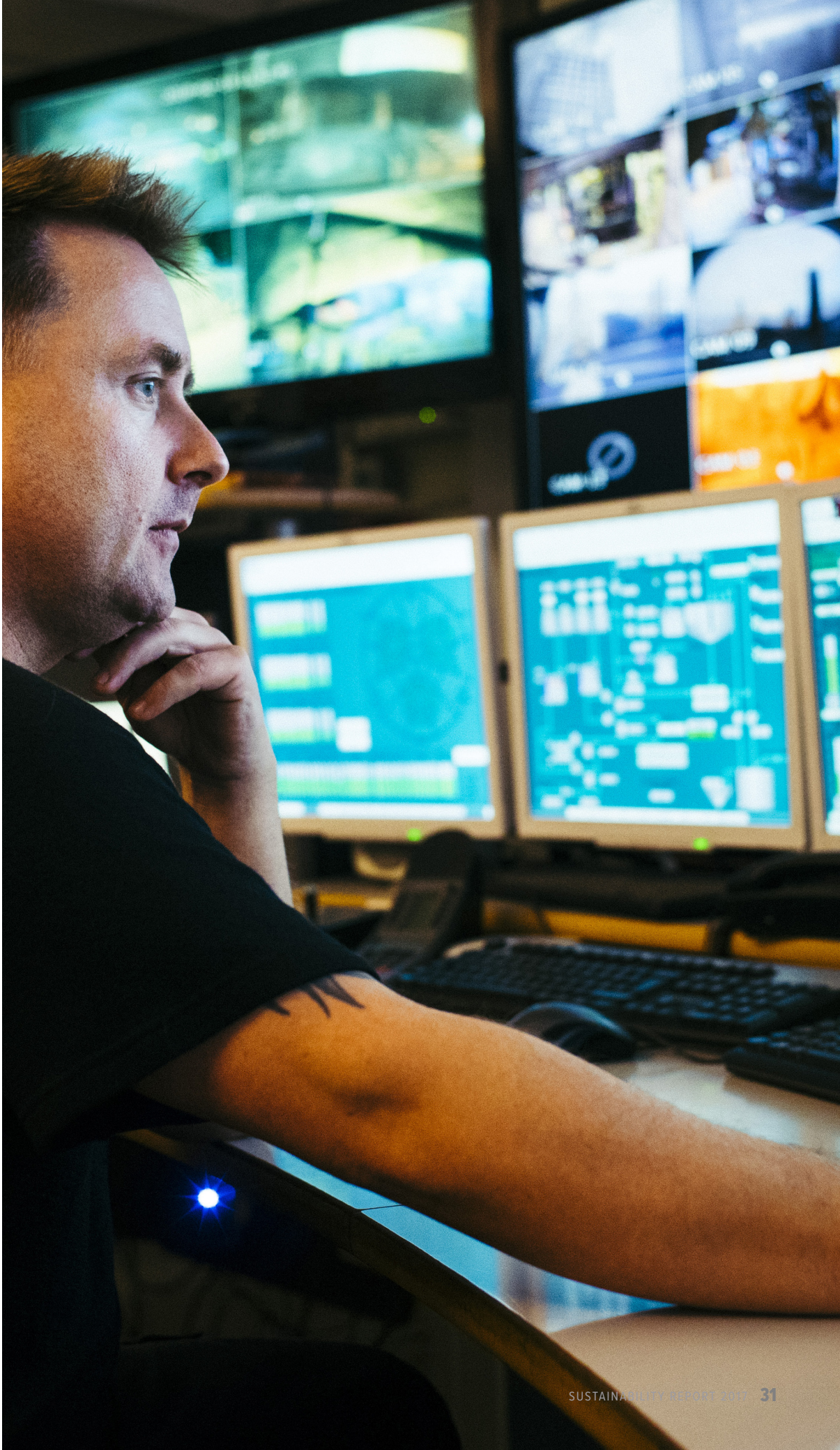
Areas for closer examination include:

- A more detailed theoretical analysis of the tracer dust technique
- More comparisons between the various measurement techniques
- Investigations into the long-term variation in air flow through the roof louvres, comparing theory and practice
- Comparison of air flow during summer conditions, when many of the doors are left open, and winter conditions when the doors are generally closed

little about how great this uncertainty is. In one case, we compared the air flow measurements with the tracer dust method and the traverse method. We obtained reasonably good agreement (see illustration). For the present, we do not know whether this agreement is due to chance or if it is real.
We have no comparisons that can tell us anything about the measurement error in the source summation method.

FURTHER DEVELOPMENT OF THE METHODS

The methods described here come with a large level of uncertainty. Given that the largest emissions from processing plants can be diffuse in nature, the correct thing to do might be to improve the measurement techniques so that the associated uncertainty is reduced and we can establish which is the best measurement technique.



IMPROVED PERFORMANCE AND RECORD OUTPUT

The emissions data for Eramet Norway Sauda in 2017 shows improvements in key areas and underlines the connection between stable production processes and good environmental performance.

No violations of the plant's emission permit were recorded. Sauda achieved reductions in measured emissions of manganese to air and in the number of complaints from neighbours. However, some brief periods of instability in production processes led to a slight increase in emissions to water of suspended substances and some metallic elements compared with last year's record low levels.
Despite these periods of instability, the Sauda plant enjoyed a record year in terms of smelter and refinery output.

STABLE PROCESSES MEAN LOW ENERGY CONSUMPTION

On the processing side, the main focus was on establishing and maintaining stable smelting processes as a key indicator of good energy performance. We achieved a 4.5% reduction in specific energy consumption per tonne produced (SEC), equivalent to 32 GWh less than budgeted. This equates to a cost saving of about NOK 10m, showing the value of establishing and maintaining stable control of primary processes over time.

We also achieved a 7% reduction in consumption of auxiliary power compared with 2012, the reference year. This was a result of optimising boiler performance and focusing on initiatives to reduce our overall energy consumption.

In autumn 2016 a new district heating plant came into operation, enabling us to increase the temperature of the water supplied for heating the town centre streets and the stadium. The process involves collecting excess cooling water with a temperature of about 40°C from the furnaces and putting it through a heat exchanger, which raises the temperature by 6–10°C. The plant has an hourly capacity of almost 80 m^3.

MULTIPLE USES FOR ENERGY SOURCES

Gas from the smelting process consists mainly of carbon monoxide (CO), which is used as an energy source for preheating and heating refractory materials. The gas is subsequently used in the production of liquid slag and metal and for heating the buildings on site.

Purified carbon monoxide is piped into a boiler, where it is mixed with air. The mixture is then burned in a combustion chamber, where water circulates through a loop of pipes. The hot water is piped to the radiators which provide heat in various buildings on site. Hot water from the boiler is also used to raise the temperature of the cooling water from the furnaces which feeds the district heating supply to the town centre streets, the football stadium and the leisure centre.

Some of the hot water is also used to preheat the water used to extract ferrous sulphate in the final treatment plant. The boiler has a maximum energy capacity of 3 MW and operates at 95% efficiency.

EFFECTIVE ACTION TO CUT DIFFUSE EMISSIONS FROM PRIMARY PROCESSING

Good process control was the defining feature of operations at Sauda in 2017, resulting in stability and record high output from the smelter and the refinery. The plant's mantra is that predictable, stable processes provide a basis for good performance in the areas of health and safety, environment and energy.

Nevertheless, we sometimes experience brief periods of instability in our processes, leading to unplanned emissions of dust to air.

In 2017 we focused on improving the overall effectiveness of many of the existing environmental protection barriers in the furnace hall operations zone. In particular, we developed new, stronger barriers to reduce unplanned dust emissions to air in both the hot and the cold zone. Most of these measures were implemented in the second half of 2017, and precipitation measurements after implementation show that the improvements have been effective in relation to our overall objective of eliminating dust emissions to the wider environment.

Research-based approach to environmental challenges

In an effort to meet targets for reducing diffuse dust emissions, process operators and specialists at Sauda continued to work closely with Eramet Norway's Trondheim-based R&D department in 2017.

The objective of this collaboration was to achieve maximum effectiveness for existing and new extractor systems.

Eramet Norway's R&D team in Trondheim (ENT) comprises three scientists working on a project basis for the Eramet Norway plants. Their areas of expertise include reducing dust emissions, process control, raw materials characterisation and manganese alloy refining. They use advanced modelling techniques in fields such as heat and mass balance, computational fluid dynamics (CFD) and statistics. The focus of our collaboration was on optimising the design and performance of extractor hoods and systems in hot processes.

Methodical, scientific approaches such as CFD and process flow modelling have led to changes in the operating procedures governing the use of extractor systems. This has helped us optimise the effectiveness of each extractor point.

FOCUS ON BETTER ENERGY UTILISATION

Eramet Norway obtained ISO 5000 energy management certification in 2014 and was recertified in December 2016 after a comprehensive audit by DNV-GL.

The certification provides a good starting point for our ongoing efforts to improve energy management. Eramet Norway has committed to a systematic drive to boost energy efficiency, which will cut costs and reduce emissions.

ENERGY MANAGEMENT TEAM

A dedicated energy management team has been set up and has been working towards the following objectives:
– Achieving the set energy targets for 2017
– Ensuring that energy-related projects are planned, implemented and followed up systematically
– Measuring and reporting the relevant key performance indicators on a monthly basis

The energy management team includes representatives from all areas of plant management and has specific responsibilities relating to the energy efficiency drive. Those projects with the greatest energy utilisation potential that the team worked on in 2017 were:
– Ensuring delivery of the project to supply hot cooling water from the refining process, with an energy content equivalent to 4.6 GWh annually, to Praxair's O_2 production facility.
– Converting the propane dryer to a CO/propane combi dryer, which is used to heat and dry refractory linings on metal shanks before these enter the production process. The result has been a 90% reduction in propane consumption compared with 2012, the reference year, and the cut in CO_2 emissions alone will be 450 tonnes annually. In cost terms, the propane reduction saves NOK 400,000 a year.

Valuable input from neighbours

The location of the Sauda plant means that many local residents are able to keep tabs on the plant's activities and emissions at all times. We invite our neighbours to join us at the plant for annual open meetings.

The neighbourhood meetings provide a good opportunity for process operators, specialists and plant managers to gain inspiration for improving the plant's environmental performance. The meetings are also an important source of information for our neighbours, giving them an insight into our environmental improvement processes. Building and maintaining good relationships with our neighbours in the community has been a key motivation for our efforts to achieve zero dust emissions at Eramet Norway Sauda.

ENERGY BALANCE STATUS FOR ERAMET NORWAY 2017

Eramet Norway's three manganese processing plants focus on systematic energy conservation to bolster the sustainability of our operations.

2.0 TWh
of energy consumed by production in 2017

535,000
tonnes of manganese alloys produced and sold in 2017

The manganese alloy industry is very energy-intensive, but Eramet Norway's three plants at Kvinesdal, Porsgrunn and Sauda all hold ISO 50001 certification as proof of their healthy energy balance sheet.
Energy consumption can be divided into three main groups (see illustration), with "electrons" and "hydrocarbons" each representing 46 and 43 per cent respectively of the total 4.4 TWh for 2016 (compared with 4.2 TWh for 2015). The remainder is accounted for by the energy used in the consumption of metallic materials (silicon and manganese) in the furnace and refining processes.

ENERGY CONSUMPTION

The consumption of 2.05 TWh of electrical energy represents 0.60 TWh, 0.72 TWh and 0.75 TWh at Porsgrunn, Sauda and Kvinesdal respectively. Coke and anthracite are primarily used as reductants in the smelting furnaces, but the energy content of 1.94 TWh is included in the balance sheet.

ENERGY USE

With a sellable production in the order of 629,000 tonnes of manganese alloys in 2017, we estimate that 2.14 TWh of energy is used in the production of these products – or roughly 46 per cent of the total energy used in the processes for standard and refined FeMn and SiMn.
The major challenge is how much energy we succeed in recovering as fuel and in heat flows, such as air and water. For 2017, this was roughly 0.4 TWh, which is about 11 per cent of the added energy. The corresponding figures for 2016 were 0.5 TWh and 11 per cent. The energy recovery plant at Kvinesdal produced about 80 GWh net, which is something less than the total capacity due to an implemented scheduled shutdown. Supplies of furnace gas to Yara's ammonia plant in Porsgrunn usually also produce a significant effect, but here as well there was a lengthy production shutdown, which reduced the volume compared with 2015. The hot water supplies to the fish farm in Kvinesdal, the compressor heat recovery plant in Porsgrunn and the internal use of furnace gas for refractory activities and building heating in Sauda are all activities that make a solid contribution to energy recycling. In Porsgrunn, a system for recycling hot water from slag beds was commissioned in 2016.

FURTHER INCREASING ENERGY RECOVERY IS A CHALLENGE

As a residual item, we also ended up with 2.1 TWh on the tap side. The energy teams at each of the processing plants are all involved in this work, ranking their plans for improvement measures according to investment needs, implementation time and potential gain. Location factors have some significance for the potential use and attractiveness of recycled energy. Use is made of public support schemes arranged via Enova. Internally, each of the three processing plants receives a dedicated annual sum that is earmarked for energy conservation measures. ●

Eramet Norway resource balance sheet 2017

PROCESSES

Raw materials

Raw materials containing manganese	936 873 tonnes
Reducing agents containing carbon	238 976 tonnes
Electrode paste containing carbon	13 390 tonnes
Raw materials containing silicon oxides	95 179 tonnes
Products containing silicon	57 174 tonnes
Products containing iron	18 095 tonnes
Products containing calcium	31 836 tonnes
Recycled raw materials containing manganese	334 345 tonnes

Energy

Electrical energy (smelting and auxiliary power)	2 047 796 MWh
Fossil energy	660 tonnes

Other inputs

Cooling water consumed (purchased and river water)	11 500 000 Nm^3
Compressed air	28 727 201 Nm^3
Process gases	36 152 tonn

- Raw materials receiving
- Raw materials processing
- Smelting
- Metal refining
- Finished goods processing
- Treatment of emissions to water and air
- Direct production support
- Indirect production support

Core products

Magnesium alloy orders	535 506 tonnes

By-products

Mn slag, resmelted material, dust for internal use	305 333 tonnes
Mn dust for external sale	22 426 tonnes
Mn waste slag for external sale/use	334 285 tonnes

Landfill waste

Sludge, metals, wood, paper	29 553 tonnes

Recycled energy

Electrical and chemical energy	346 022 tonnes

Emissions to air

Chemical elements	115 tonnes
CO_2	724 951 tonnes

Emissions to water

Chemical elements	2 tonnes

ERAMET NORWAY ENERGY BALANCE 2017

USING WASTE HEAT FROM FURNACE SLAG TO CLEAN MERCURY FILTER

Eramet Norway Porsgrunn is now using the hot water produced in the process of cooling manganese slag to flush out mercury deposits from the furnace gas filter.

1.3M
NOK invested in the project

Twice a year, the mercury removal unit (MRU) had to be shut down for cleaning, to prevent excessive build-up of tar in the electrostatic filter. The cleaning process was risky, since it involved entry into a closed space and flushing with an ammonia solution. What's more, the costs of cleaning the filter and safely disposing of tar containing mercury ran to almost NOK 1m annually. Staff at Porsgrunn realised they needed to seek out alternative solutions.

A CHANCE IDEA THAT HAD LEGS

The team in charge of the electrostatic filter had long been looking for a way to improve the process. When a supplier performing an unscheduled cleaning achieved satisfactory results using hot water instead of the ammonia solution, the team had an idea.

The Porsgrunn plant produces plenty of hot water. For instance, hot slag from furnace 10 is flushed with water to cool it down, and the heated waste water is then collected in a tank.

The electrostatic filter team installed an extra tank and pump and an automated filter washing system, which flushes the filter with hot water daily to prevent tar deposits and mercury accumulation.

The project involved capital expenditure of NOK 1.3m and was 33% funded by ENOVA. Construction was completed in autumn 2016 and the system came on stream in February 2018.

FEWER SHUTDOWNS AND LOWER COSTS

Daily flushing of the electrostatic filter with hot water has been successful in preventing a build-up of mercury. The water is recycled in the existing water treatment plant.

Overall, the initiative has yielded cost savings of almost NOK 1m and a more stable production process, where it is no longer necessary to halt furnace operations while the MRU is shut down for cleaning.

Daily flushing of the electrostatic filter with hot water has been a success.

When water is used to cool hot slag, its temperature rises. The heated waste water is reused to flush out the filter.

SUSTAINABLE SUPPLIER RELATIONSHIPS CREATE VALUE

Eramet Norway depends on its suppliers. We therefore maintain a network of suppliers committed to long-term, mutually beneficial relationships and expect the highest standards from our business partners.

The standards we expect from our suppliers and business partners relate to reputation, sustainability and financial stability. Partners that live up to our expectations are rewarded with a predictable, mutually challenging working relationship. We seek to establish common ground on which to build relationships that result in innovative improvement initiatives, which in turn enable both sides to compete better.

ALL ABOUT TEAMWORK

Suppliers can represent a significant and growing risk factor in terms of sustainability and business reputation. At Eramet Norway, we screen potential new suppliers closely to ensure they meet our requirements. We also systematically review the compliance and development activities of our existing suppliers, and our working relationship with the suppliers is crucially important. We set out clear requirements for ourselves and our business partners. All ERAMET employees have a duty to familiarise themselves with and comply with the group's code of ethics. We maintain this requirement in our contracts, which require suppliers to uphold ERAMET's ethical principles when performing work and providing services. ERAMET's Responsible Purchasing Charter is available on the group's website (eramet.com). Suppliers are encouraged to report any breach of the code of ethics on ERAMET's part by email to varsel@eramet-group.com.

EVERYONE CAN DO THEIR BIT

On request, suppliers must be able to document compliance with the guidelines. The tools used include self-certification, performance reviews, and working environment audits of production sites. To enable us to map and monitor the entire value chain, suppliers must provide the names and contact details of any subcontractors. Internally at Eramet Norway, and in our dealings with other parts of the group, we work closely across departmental boundaries to raise awareness of ethics and reduce the risk of ethical violations, corruption and contractual breaches in our value chains.

LIFECYCLE COST IS KEY

Eramet Norway aims to be a demanding but attractive customer offering clear, fair contracts and relationships based on trust, openness and traceability.

All our suppliers must meet fundamental standards with regard to human rights, employee rights and the environment.

We must be able to have confidence in the products and services we purchase. All our purchasing decisions are based on lifecycle cost and not just acquisition cost. ●

Eramet Norway exercises social responsibility by:

- Owners receiving an expected return on their invested capital
- Employees feeling a sense of security for themselves and for their families
- Our suppliers having a demanding customer
- Our customers getting their products on time and with the agreed quality
- Keeping our environmental impact to a minimum
- Taking the initiative to make changes in response to circumstances
- Producing useful products needed by the world in a way that is environmentally effective

Robust industrial regions:

Eramet Norway is also interested in helping to build robust industrial regions. Initiatives that strengthen social structures in communities where we are located also strengthen our competitive position.

A robust industrial region is characterised by:

- Equitable and stable welfare provision
- A competitive, profitable and adaptable commercial sector
- Good access to skills
- Access to a varied jobs market, accommodation and services

STRICTER CODE OF ETHICS

A new reporting system is designed to ensure there are no negative consequences for anyone reporting a breach of ERAMET's code of ethics.

Corruption, fraud and workplace harassment – these are all examples of activities that would constitute violations of ERAMET's code of ethics.

In 2017, ERAMET set up a network of ethics managers and ethics ambassadors in all its subsidiaries and territories worldwide. At Eramet Norway, then finance director Mickael Panol, and now Jose Manuel Sanchez, was appointed as ethics manager, while Marianne Synnes Kaasa is the ethics ambassador. They work together to promote an ethical workplace culture at Eramet Norway.

Eramet Norway has published its code of ethics on the company's intranet. The handbook outlines the company's values and guidelines, and is intended to ensure a good working environment for all employees and responsible behaviour vis-à-vis the various stakeholders.

"An effective reporting system also makes sound financial sense, since it bolsters the group's reputation," said Mickael Panol. "Marianne and I are available to explain the rules and resolve any problems that might arise from applying them."

The email address varsel@erametgroup.com can be used by all ERAMET employees, and by ERAMET's customers and partners, if they believe there has been any violation of a principle or value set out in the code of ethics.

Any knowledge or suspicion of the following should be reported:

- Corruption, fraud or conflict of interest
- Anti-competitive actions
- Discrimination and harassment in the workplace
- Behaviour contrary to the group's guidelines and standards on health, hygiene, workplace safety or environmental protection
- Serious violation or risk of violation of the human rights of the group's employees or other persons affected by the group's operations

ERAMET NORWAY'S CLIMATE AND ENERGY ROADMAP

Eramet Norway produces useful products in a resource-efficient way. In the wake of the processing industry roadmap and the risk analysis undertaken by the company in early 2017, Eramet Norway's board has agreed to create a roadmap for climate, energy and environment through to 2030.

In this year's sustainability report we describe our activities relating to climate and energy. The purpose of Eramet Norway's roadmap is to provide a stronger basis for achieving our goals and enhancing our competitive position through good strategic planning and effective delivery of development processes and projects. Several factors influence the process of setting our long-term climate, energy and environmental goals:

EXPECTATIONS

Society's expectations of us, as expressed through established national and international objectives, targets and regulations – and through how the wider community envisages the role of our business in a future low-carbon, low-emissions society.

COMPETITIVE POSITION

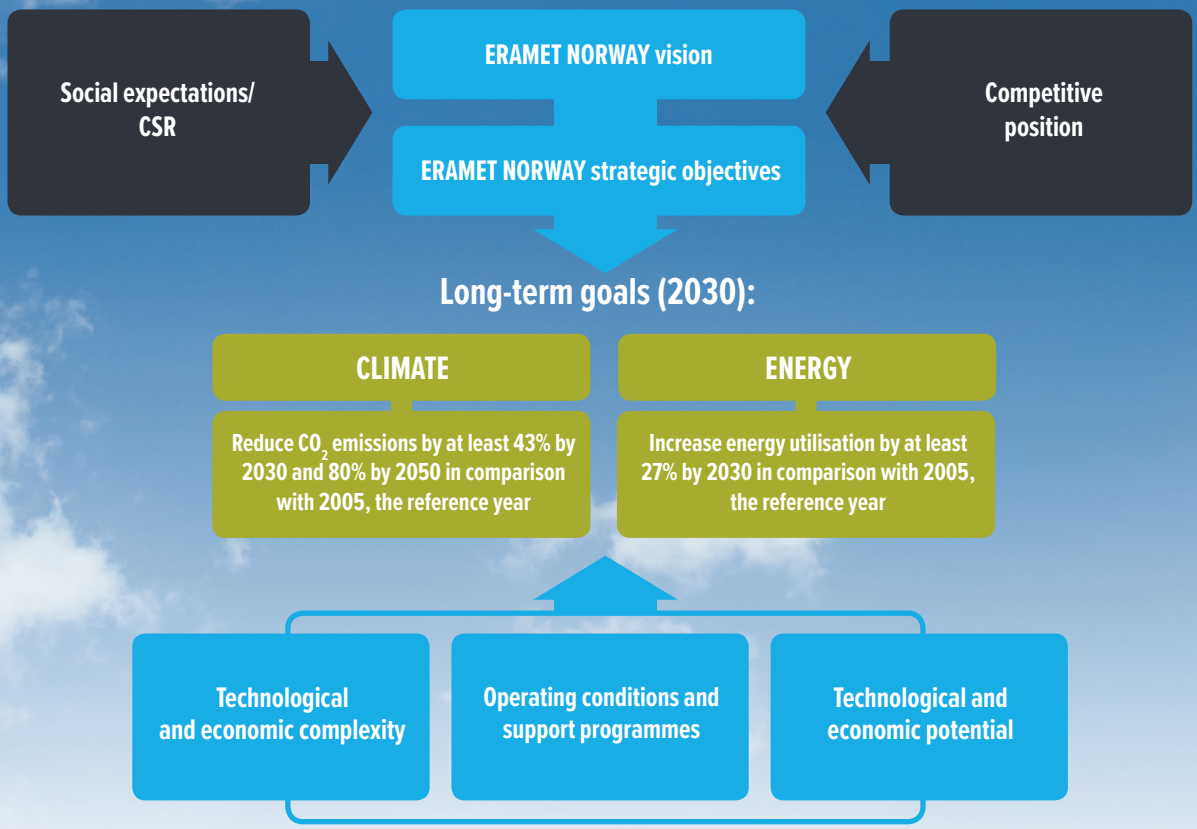
Our competitive position in the market, defined by internal strengths and weaknesses and external opportunities and threats.

NEW SOLUTIONS

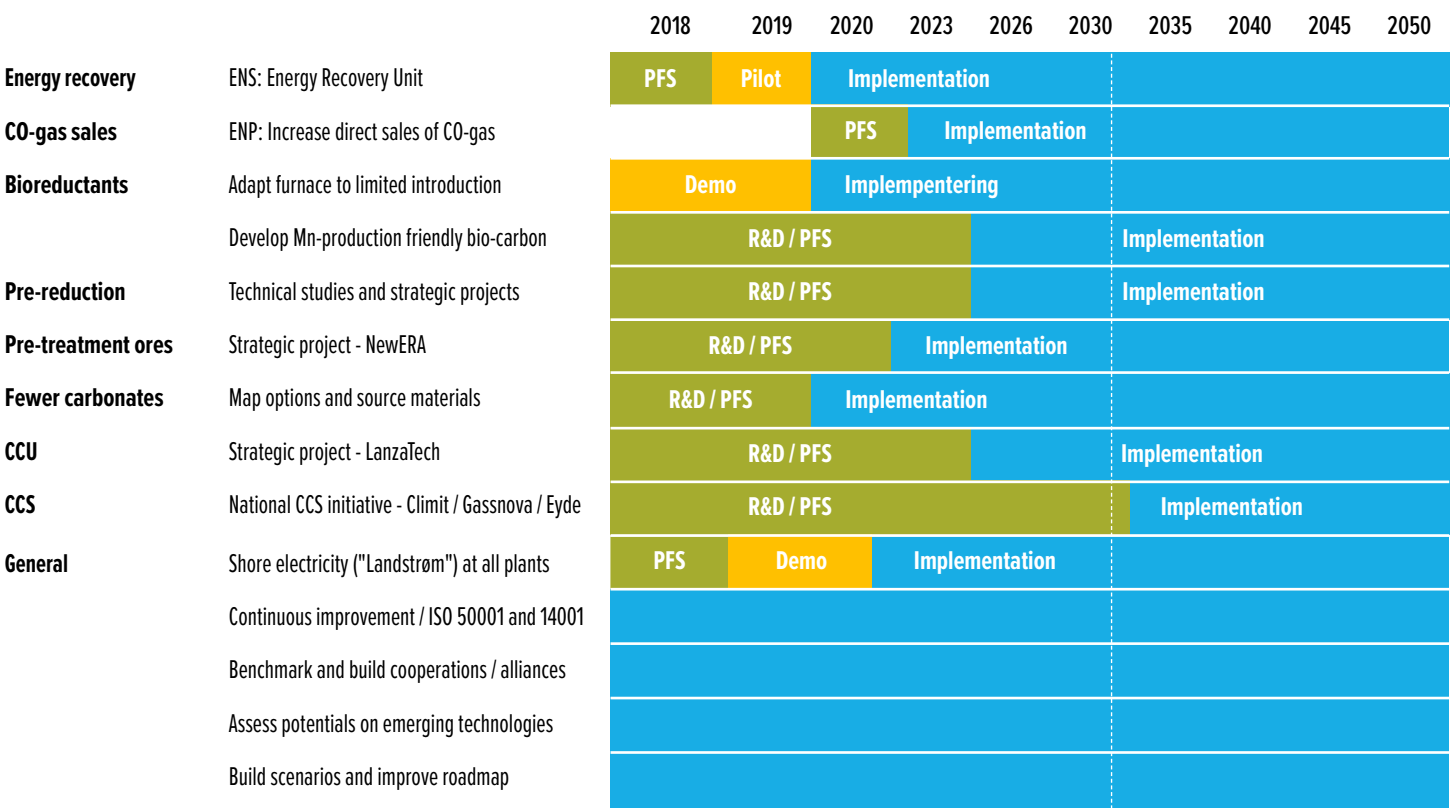
Technological and business opportunities resulting from new technological solutions, balanced against the complexity of developing and implementing these.

OPERATING CONDITIONS

Overall conditions relating to climate, energy and environment, including research policy and access to relevant support and funding programmes for developing and implementing new technology.



Climate and energy roadmap:



CAMERAS HELPING TO CUT DUST EMISSIONS

There's no denying the environmental impact of Eramet Norway's processing operations, and dust emissions are a particular problem in the vicinity of the plants. Measuring dust levels is one practical step we can take to protect the environment, as the Kvinesdal plant showed in 2017.

One of the cameras, with the plant in the background.

Eramet Norway Kvinesdal's overall objective is to reduce dust pollution to a minimum.

FOCUS ON CUTTING DUST EMISSIONS

In 2017 we pursued various large- and small-scale initiatives to reduce dust emissions to the area around the plant. The smaller initiatives included introducing working procedures that minimise dust creation, while two of the larger initiatives were to install a dust meter and monitoring cameras.

As a result, overall dust emissions to the area around the Kvinesdal plant are now monitored continuously. The cameras have been installed at strategic locations in the plant, and we use the images to identify the direct impact of the production process on air quality in the area.

The dust meter, which operates in tandem with the cameras, continuously measures dust concentrations in our immediate surroundings.

Thanks to the cameras and the dust meter, we can document the effects the plant has on its surroundings and quantify the environmental impact of any one-off incidents.

Identifying dust in the surrounding area enables us to adjust our processes to minimise our environmental impact.

CONVINCING RESULTS

Measurements conducted by Eramet Norway in 2017 show that Kvinesdal meets the air quality standards for manganese plants. The surrounding air must not contain more than 150 nanograms of manganese per cubic metre (1 nanogram = 0.000000001 gram). The measurements at Kvinesdal found 122 nanograms per cubic metre.

What this means in practice is that we can learn from periods when no dust emissions are recorded and adopt the process parameters from these periods as best practice. Equally important is to identify discrepancies recorded at other times and adjust the process parameters to avoid a repetition.

For Eramet Norway Kvinesdal, these are important steps in the right direction towards the goal of zero impact on our local environment.

Dust meter readings showed that we met the air quality standards for manganese plants in 2017.

PAH-FREE ELECTRODE PASTE – A BIG STEP IN THE RIGHT DIRECTION

The first successful industrial test of PAH-free electrode paste in a large Søderberg electrode marked a milestone in Eramet Norway's drive to reduce emissions of and workplace exposure to polycyclic aromatic hydrocarbons (PAH).

Coal tar pitch has been an essential component of electrode paste since Carl Wilhelm Søderberg invented the electrode that now bears his name a century ago. In the intervening decades, industry has failed to find a workable alternative to coal tar based binding agents in large furnaces.

The test therefore represents a breakthrough not just for Eramet but for the smelting industry as a whole.

We are now seeing the emergence of greener, PAH-free electrode paste.

TARGETING PHASE-OUT BY 2020

After thorough preparation, the test was conducted over a six-month period in 2017 at Eramet Norway's SiMn smelter in Kvinesdal. It followed a similar test of a low-PAH electrode paste. Much work remains to be done before PAH-free electrode paste can be approved for use in our smelters. In partnership with suppliers and research institutes, we have an ambitious programme of further trials scheduled for 2018 and 2019, with the goal of phasing out all coal tar based electrode paste by 2020.

TOWARDS A PAH-FREE WORKPLACE

Coal tar pitch contains various PAH compounds and is defined in the European REACH regulation as a substance of very high concern (SVHC). It is on a list of candidates for the REACH authorisation scheme, and the industry may be required to apply for authorisation to use coal tar based electrode paste in 2020.

PORSGRUNN FOCUSING ON NOISE ISSUES

Eramet Norway Porsgrunn takes noise issues seriously. Since noise will always be an unavoidable aspect of our business, staying actively focused on reducing external noise levels is all the more important.

55 dB
highest noise levels during daytime

The Herøya plant in Porsgrunn wants to be a good neighbour and responds proactively to complaints and suggestions from the surrounding community. We have a long tradition of holding annual neighbourhood meetings to keep our neighbours informed of our activities and environmental initiatives.

GOOD NEIGHBOURS

In our day-to-day business, we maintain regular dialogue with our closest neighbours regarding current issues. Our neighbours are very helpful in identifying problems and providing input on proposed improvements.

As part of our systematic noise reduction efforts, we have historically conducted noise measurements annually. Every three years, we have called in Det Norske Veritas (DNV) to conduct the measurements. To improve the system and comply with the terms of our new emission permit from the Norwegian Environment Agency (Miljødirektoratet), we also undertook noise mapping in 2017.

NEW NOISE MEASUREMENT TECHNIQUE

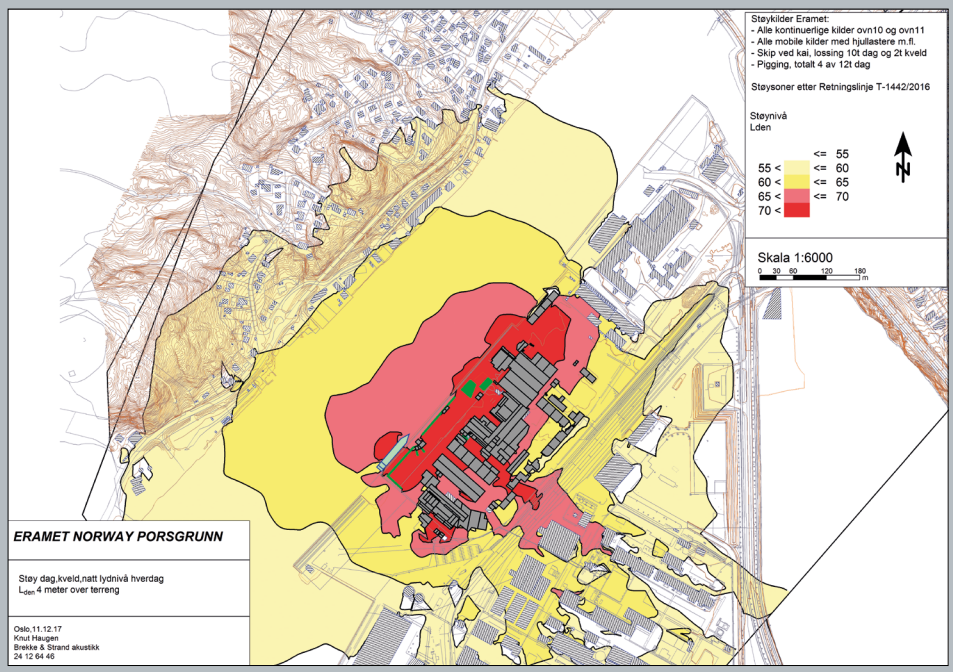
To carry out the noise mapping, we selected Brekke & Strand Akustikk AS rather than DNV. Our choice was motivated by the desire for a fresh perspective on the situation, preferably from a consultant with local knowledge of the industry.

The measurement methodology was the same as that used by DNV and meets current standards, but the calculations were based on slightly different assumptions and did not subtract noise from the neighbouring Yara plant.

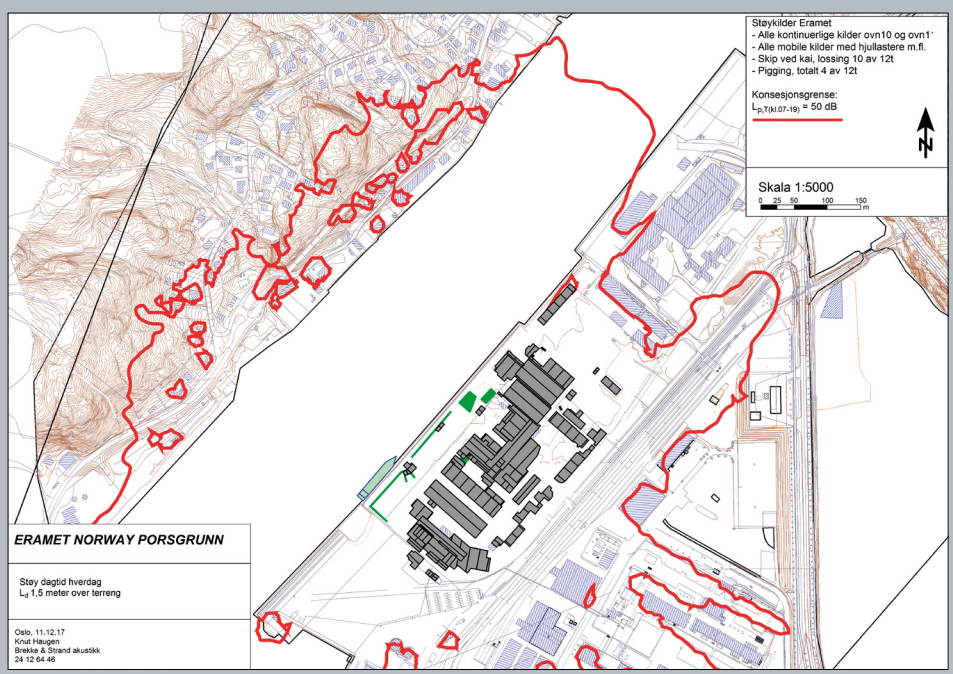
The Brekke & Strand report shows noise levels of 55 dB during daytime at the most exposed calculation point. This is 5 dB over the limit set in the emission permit. The consultants point out that the calculations are based on a very high number of simultaneous noise sources. At night, noise levels are lower and are just 1 dB over the limit (51 dB). Previous noise evaluations for licensing purposes were based on noise measurements rather than on calculation-based noise mapping. The latter identifies any issues more clearly.

The main noise sources are:
– Pigging of ladles
– The chimney of the finished goods crusher plant
– Unloading of ore at Assmang
– Raw material movements using wheel loaders

On 20 March 2018, Miljødirektoratet received objections from neighbouring residents in Knardalstrand regarding noise from Eramet Norway Porsgrunn, Yara and timber unloading operations at Tinnfosskaia. Noise from ships, fans and other sources was cited as a growing problem. It was also mentioned that Eramet has vessels docking at weekends, which are unloaded during daytime using grabbers and other machinery.



Noise map based on acoustic camera measurements. Acoustic image captured at south end of dockside crane track facing noise sources at furnace 10. The top image also shows contributions from activity at the docks and at Yara.



Measurements with acoustic eraser (red arrow).

WHAT ARE WE DOING TO REDUCE NOISE?

Using noise measurements, noise mapping and feedback from neighbours, we have devised a series of measures to cut noise emissions to a level that complies with the terms of our licence and reduces annoyance. Somewhat paradoxically, the noise sources that put us over the permitted limit are not necessarily the ones perceived as the most annoying by our neighbours.

Noise abatement measures comprise a mixture of technical projects and improvements to operating practice.

Highest-priority technical measures:
– Chimney muffler for the finished goods crusher plant
– Mufflers for various fans around furnace 11
– Environmental filter for furnace 11 (fan, check existing mufflers)
– Ladle flushing process

OPERATIONAL CHANGES

Big changes have taken place over the past decade with regard to unloading vessel cargoes. There used to be 12 large vessels of 27,000 tonnes arriving annually, which would dock for five days and unload raw materials continuously. The cascading materials and the grabber operations generated a lot of noise.

In 2012 we began the transition to smaller, self-discharging vessels of 5,000–6,000 tonnes, which dock for much shorter periods. All the large vessels have now been phased out, which has eliminated the need for overnight unloading.

Unloading operations are now restricted to 0700–2200 hrs on weekdays and 0830–2200 hrs at weekends.

We use wheel loaders to handle the raw materials after they have been unloaded from the ship. This activity sometimes continues round the clock. As production has increased in recent years, so has the need to keep the furnaces supplied with raw materials, so there has been more wheel loader activity. To reduce evening and overnight noise levels as much as possible, we have specifically reviewed which raw materials are moved at which time of day. What this means in practice is that hard, heavy materials such as ore and quartz are moved during the day, while lighter materials such as coke and sinter are moved at night.

Noise patterns have also changed slightly in the past few years because almost no unloading now takes place at Tinnfosskaia. The majority of raw materials are now unloaded at Eramet Norway Porsgrunn's own dock.

WASTE HEAT FROM ERAMET NORWAY BENEFITS SAUDA RESIDENTS

Back in the year 2000, Eramet Norway teamed up with power company Saudefaldene to put waste heat from the smelter to good use in the local community.

ENOVA
granted funding for the project in 2018

District heating pipes were installed under the streets in Sauda town centre to keep them ice- and snow-free in winter. Subsequently, underground heating was installed in the town's new stadium.

In 2013 the local economic development agency, Sauda Vekst, stepped up efforts to increase energy reuse in Sauda.

Key components of the programme included:
– Setting up a separate company, Sauda Fjernvarme AS (SFV), owned jointly by the district council and local businesses with relevant expertise
– Conducting a feasibility study on waste energy reuse in partnership with Norsk Energi
– Putting in place a long-term supply contract between Eramet Norway and Sauda Fjernvarme

IMPROVED QUALITY OF LIFE FOR SAUDA RESIDENTS

In 2016 the district heating system was extended to the Saudahallen leisure centre and the new outdoor swimming pool. At the same time, preparatory works were undertaken to connect the renovated community centre, opening in summer 2018, to district heating.

In 2017 planning work started on the next phase of the district heating network. This will serve Sauda upper secondary school, Fløgstad school and the former hospital, which now houses a long-term care facility and a medical centre. In early 2018, Enova agreed to provide financial support for this project through its district heating programme.

JUST THE START

Sauda Fjernvarme is aiming to progressively expand the use of waste heat from the smelter over the years ahead. Eramet Norway's major energy recycling project (see article about NewERA project on page 44) will also greatly increase the potential for using waste energy to create value.

Sauda Fjernvarme will actively seek industrial opportunities for using waste heat, such as production processes that require large amounts of thermal energy.

ERAMET NORWAY

WASTE HEAT SUPPLIER

- Greater energy utilisation
- Improved climate and energy balance
- Potential for increased revenue
- Potential for reduced environmental costs
- Enhanced reputation

WASTE HEAT USERS

- Improved climate and energy balance
- Proper energy utilisation
- Lower energy costs
- Desirable place to live
- Public health
- Tourism and commerce
- Economic development
- Enhanced reputation

SAUDA FJERNVARME AS

Transforming waste heat into a community resource

A stronger community

- Basis for innovation
- Safeguarding existing jobs
- Skills development

Joint venture by local partners

- KLIMA OG ENERGITEKNIKK AS — 26 %
- SAUDA INSTALLASJON AS — 26 %
- SAUDA COUNCIL — 48 %

District heating is already supplied to Sauda's open-air swimming pool and stadium. The leisure centre and the renovated community centre will also be supplied from summer 2018.

SLAG POSSESSES QUALITIES WITH A WIDE USE POTENTIAL

In 2017, Eramet Norway was tasked with the job of using slag in a number of situations. Depending on the use objective, slag can be broken down into different size fractions:

– For landfilling on land or under water, slag is used in fractions of 0–500 mm.
– For capping of contaminated seabed sediments, slag is crushed down to a grain size of 0–8 mm.
– Slag is used as a coarser top layer (14–64 mm) in situations where capping material needs to be protected against erosion.

SLAG IS AN ENVIRONMENTALLY FRIENDLY PRODUCT

In order for slag or other materials to be used for landfill/capping on land or under water, there are strict requirements regarding its chemical properties.

The special properties of slag are that it is formed under extremely high temperatures, it is as hard as glass, and it is chemically stable. These properties make slag an environmentally friendly product.

Because slag is formed from molten ore or rocks, it can be compared with volcanic rock types. Analyses show that slag consists primarily of the minerals, SiO2 (43%), CaO (20%), Al2O3 (15%), MnO (8%), and MgO (8%).

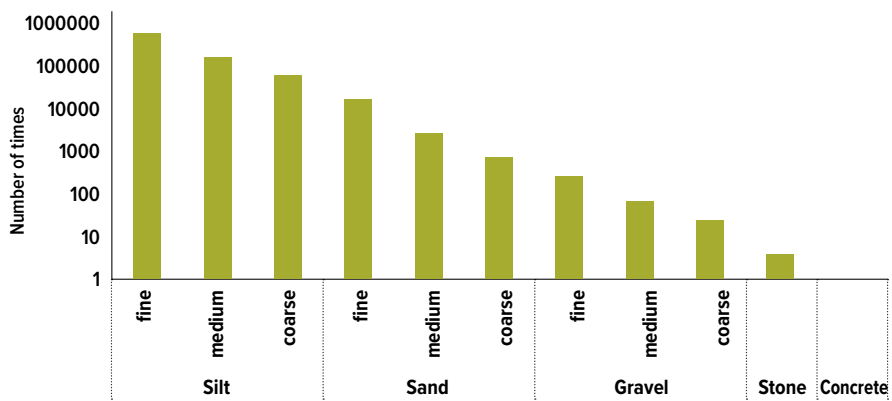
MINOR LEACHING OF INORGANIC ENVIRONMENTAL TOXINS

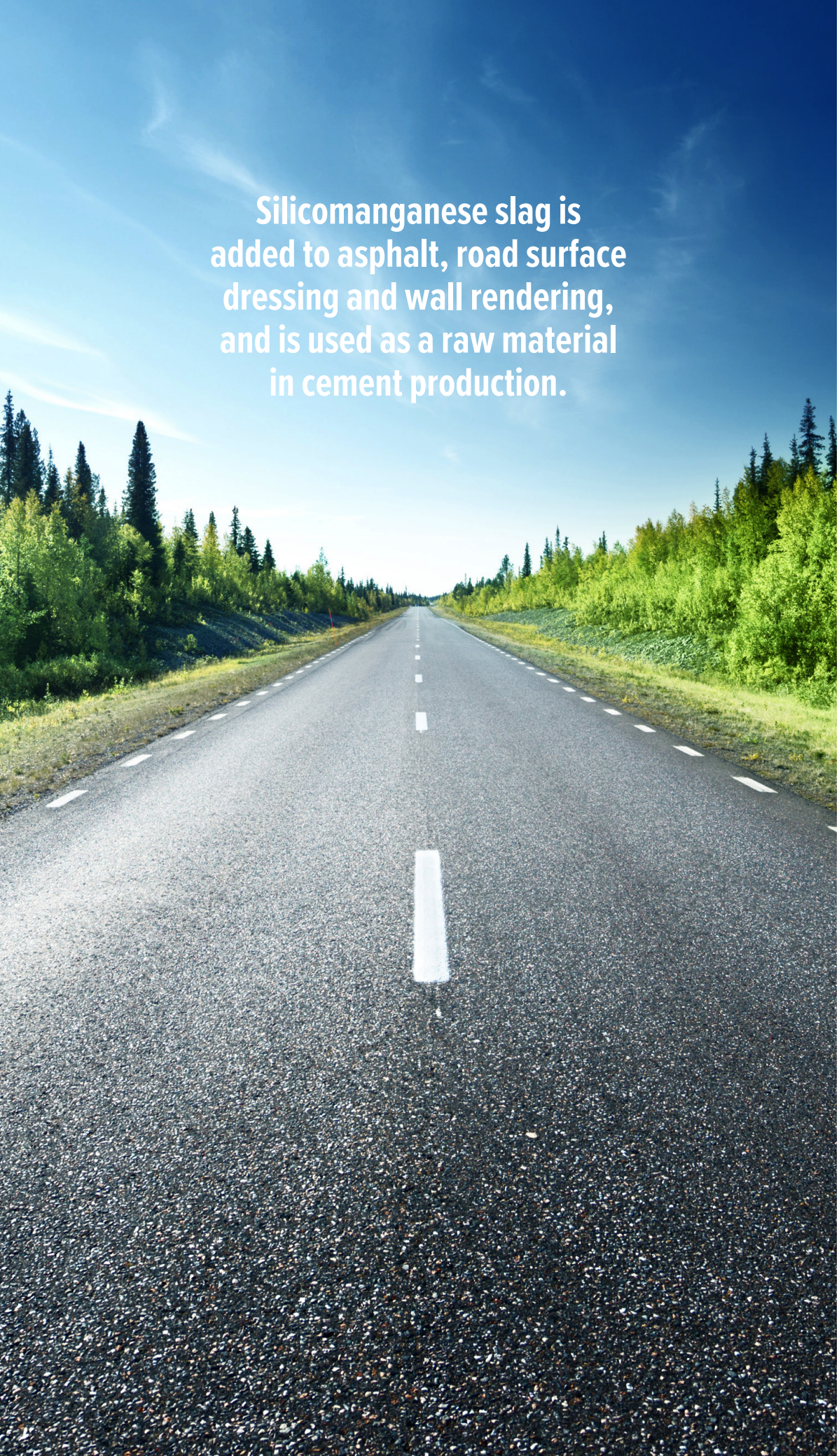
With reference to the Norwegian Environment Agency's capping guidelines, the following tests have been carried out: shake test (measures acute leaching) and column test (measures long-term leaching). The results show minor leaching of inorganic environmental toxins. There are some exceedances of the strict criteria for copper (Cu) and zinc (Zn), but the leaching is less than what is observed in natural rock types used nowadays for sediment capping.

HOW DOES SLAG BEHAVE ON LAND AND IN WATER?

Leaching of environmental toxins from slag or other products is proportional to the magnitude of the surface area that is in direct contact with water. This means that there is a greater potential for leaching from fine-grained material. In general, in handling contaminated soils, one can assume that particles larger than 25 mm can be disposed of freely if they are not obviously contaminated. Leaching tests were carried out on soil masses within the size range of 0–4 mm, i.e. about the same grain size as is used in sediment capping. In landfilling on land and in the water, coarse gravel up to 20–600 mm in diameter is used. In coarse landfill masses, the accessible surface areas that are in contact with water

Difference in binding and leaching potential





comprise less than 1/100 of the masses that were tested. One can therefore expect much less leaching from the coarser masses.

WHAT DOCUMENTARY WORK HAS BEEN DONE?

Slag samples from the Kvinesdal plant were crushed down to a size of 0–4 mm and sent to the Aquateam COWI laboratory, where they underwent a long series of tests to document leaching potential. The testing consisted of grain size distribution analysis, leaching tests (shake test and column test) and ecotoxicological testing to determine the potential effect on biota in the recipient water. Water samples from the leaching tests were sent to the accredited laboratories, Eurofins and ALS, where an X-ray diffraction (XRD) analysis was also carried out to determine mineralogical composition. In order to have slag approved as a capping material, supplementary leaching tests were carried out in 2018.

Polished slag surface, with fragments of quartz, limestone and coke visible.

NewERA PROJECT CLOSE TO IMPLEMENTATION

One of our goals at Eramet Norway is to have the smallest environmental footprint in our industry.

The NewERA project is all about developing and implementing new, climate-friendly technology with significant potential to improve energy utilisation. The project is a manifestation of our goal to reduce Eramet Norway's environmental footprint.

We aim to achieve the following outcomes:

- Greater efficiency in our core processes
- Improved overall resource utilisation
- Higher environmental standards

Main objectives of the NewERA project:

- Increase energy utilisation by at least 250 GWh (30% reduction in energy waste)
- Improve the stability of furnace processes and reduce specific energy consumption in the production of manganese alloys by at least 6%
- Reduce CO_2 emissions per tonne of output by at least 2%
- Ensure sustainable handling of by-products and waste materials

We undertook the initial development stages of the project in 2015 and 2016. In 2017 we launched two separate feasibility studies.

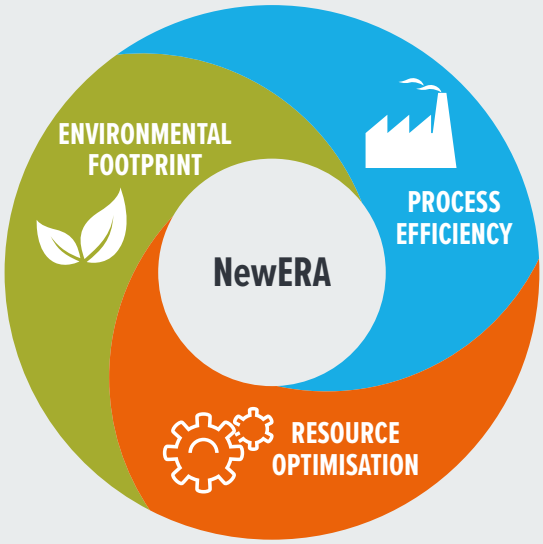
1. Energy recycling:
We are working on a detailed project plan and capital expenditure programme for a pilot installation, which we aim to implement in 2018.

Enova is supporting this project as part of its industrial pilot programme launched in 2017.

2. Drying/securing and agglomeration of by-products and waste materials:
The main objective is to determine our preferred technological concept for agglomeration and to prepare for the next stage of project development.

Enova is supporting this part of the project throughout the pilot study phase.

ERAMET's technology centre at Trappes, near Paris, is developing new technology aimed at increasing process efficiency while reducing environmental footprint.



An article from Eramet Norway's 2013 sustainability report

One of Bellona's key allies

Environmental challenges call for long-term thinking. Twenty years ago, who would have predicted that, in 2014, Bellona would view Eramet Norway and the processing industry as key allies in the drive for a cleaner, more energy-efficient and sustainable world?

A glance in the rear-view mirror conjures up images of thick, unfiltered smoke pouring from factory chimneys, illegally buried barrels of toxic waste, and chimney-climbing protesters. Images of workers scared for their own safety in the workplace, but equally scared to report the problems. Images like these remain etched on many people's memories, colouring their view of the processing industry as a polluting monster best kept at a safe distance.

Now, as we stand alongside Eramet Norway campaigning for incentives for carbon capture and storage, we do so because the processing industry, and Eramet Norway in particular, has shown that a comprehensive, systematic program of green initiatives over time can create one of the cleanest, most energy-efficient ferroalloy industries in the world. We can say that the environmental fight was worth it. Over 10 years ago, we campaigned together against plans to make businesses pay a tax on sulfur emissions straight into government coffers, with no strings attached. Instead, we believed the money should be paid into a dedicated fund and used specifically to clean up sulfur pollution. Our combined effort paid off. Industrial sulfur emissions have been cut dramatically.

When the government again proposed a tax on emissions, this time on nitrogen oxides (NOx), we rallied the troops once more. Together, we successfully argued that the finance ministry was not in a position to reduce emissions, and so a well-functioning NOx fund was set up. Although Bellona still goes after environmental offenders, we are now setting our sights further and further into the future. Eramet Norway is among the industries that need years to plan and carry out capital projects that will last until 2050 and beyond. We know that failing to proactively take environmental considerations into account will undermine future profitability. So it is our job to seek out industry partners and challenge them to work with us to create examples of best practice that show the way forward in the fight for a sustainable society. This society needs the products of the ferroalloy industry, and it needs those products to be produced using minimal energy and without harmful emissions.

The prerequisites are extensive capital expenditure and a favourable regulatory environment created by authorities bold enough to rise to the environmental challenges. The fact is, we cannot create a renewable world without ferroalloys.

by Frederic Hauge, founder and president, Bellona Foundation

BELLONA FOUNDATION

The Bellona Foundation is an independent not-for-profit organization that aims to meet and fight the world's climate challenges by identifying and implementing sustainable environmental solutions. The foundation is working to achieve greater ecological understanding and better protection of nature, the environment and health. Bellona is engaged in a wide spectrum of current national and international environmental issues around the world.

Eramet Norway and the Bellona Foundation have a formal working relationship, the objective of which is to draw on each other's expertise to improve the company's environmental performance.

IN RETROSPECT

An article from Eramet Norway's 2016 sustainability report

ENERGY-MARKING

GUARANTEES OF ORIGIN ARE A MARKING SCHEME FOR ELECTRICITY

Guarantees of origin are a labelling scheme for electricity that shows the electricity customer that a certain quantity of energy has been generated from a specified energy source. The scheme was introduced with the EU's first renewables directive (Directive 2001/77/EC) in 2001 in order to give consumers a choice between renewable and non-renewable energy. At the same time, energy producers who sell guarantees of origin receive an additional income from their renewable energy production.

It is the energy suppliers who buy the guarantees of origin from energy producers. The energy suppliers can then give a guarantee to the customer that the energy the customer is paying for is renewable, and that an amount of renewable energy is being generated that is equivalent to the amount used by the customer.

Source: The Norwegian Water Resources and Energy Directorate (NVE)

Neither the climate nor Norwegian value creation are served by a system that contributes to green-washing coal power generation

GREEN ENERGY SHOULD PAY FOR ITSELF

Ole Børge Ytredal, Director of the Federation of Norwegian industries

One of the most important advantages for industrial production in Norway is emissions-free and green hydroelectric power.

Green hydroelectric power, combined with Norway's position as one of the world's most technologically-advanced countries, provides an extremely good basis for continuing industrial production in Norway. The government also stresses this in its Industrial Report, which was presented on 31 March.

Going on the offensive on environmentally-friendly initiative

Industry is now high on the political agenda because we have emissions-free hydroelectric power and because industrial companies in Norway, in their road-map for increased value-creation and reduced emissions up to the year 2050, have adopted an extremely aggressive attitude to continued environmentally-friendly initiatives in Norway.

The underlying principle for further industrial initiatives is energy security for competitive conditions. It is important that there should be no doubt that energy bought in Norway really is green! Physics says so, but a financial instrument known as guarantees of origin has been created which is contributing the confusion on this point.

Industry in Norway runs on emissions-free energy

The Federation of Norwegian Industry is actively working to change the guarantees of origin system in order to eliminate any doubt that Norwegian industrial production uses emissions-free energy. Following consideration of the Energy Report last summer, the Storting has instructed the government to look more closely at the system.

The system has its origins in Brussels. The draft for a new renewables directive envisages a continuation of the system, but at the same time there is also scope for adaptations that ensure that the green nature of Norwegian hydroelectric power and industrial production is not undermined.

Neither the climate nor Norwegian value-creation is served by a system of guarantees of origin that contributes to the green-washing of energy production based on burning coal. The system has to be changed, and the Federation of Norwegian Industry aims to play a constructive part in ensuring that this happens.

An article from Eramet Norway's 2015 sustainability report

A road map for the processing industry

Øyvind Slåke
Technical Director of the Energy and Environmental Department
The Federation of Norwegian Industry

The climate meeting at Paris COP21 set a number of ambitious climate targets. The target of the average temperature on earth not increasing by more than two degrees in the period to 2050 is still in place, but it was also decided to limit this increase to 1.5 degrees.

COP21 also decided that from 2050 to 2100, greenhouse gas emissions from human activity should not exceed levels that can be absorbed naturally and by means of CCS. This will provide the framework for the low-emission society of the future.

In order to ensure that Norwegian society is prepared for this low-emission society, the Norwegian government has commissioned an expert committee to prepare a strategy for green competitiveness. The committee has been tasked with presenting proposals for an overall strategy to ensure that industry will still be able to compete globally once environmental policy is reinforced by stricter measures.

A new road map for an innovative and value-creating Norwegian processing industry

Just before the close of the year, the committee asked the Federation of Norwegian Industry to draw up a road map for the processing industry for the period leading up to the low-emission society of 2050. The Federation, which is the industrial organisation for the processing industry, enthusiastically accepted the challenge, and work on drawing up the road map is underway, with submission to the expert committee planned for May 2016.

The Norwegian processing industry is extremely energy-efficient and based on clean, renewable hydroelectric power, making it the world-leader in terms of climate and the environment. It represents an important part of Norwegian wealth-creation and accounts for significant expert values. The companies that go to make up the processing industry are located throughout the country, with most being important keystone industries in their respective local communities. The Federation of Norwegian Industry believes that the processing industry should account for a larger proportion of Norwegian wealth-creation in the low-emission society than it does at present. For this to happen, there has to be a demand for the industry's products in the global market, as well as competitive conditions and access to renewable energy at competitive prices, and the industry has to reduce its greenhouse gas emissions in line with the EU-ETS and international agreements.

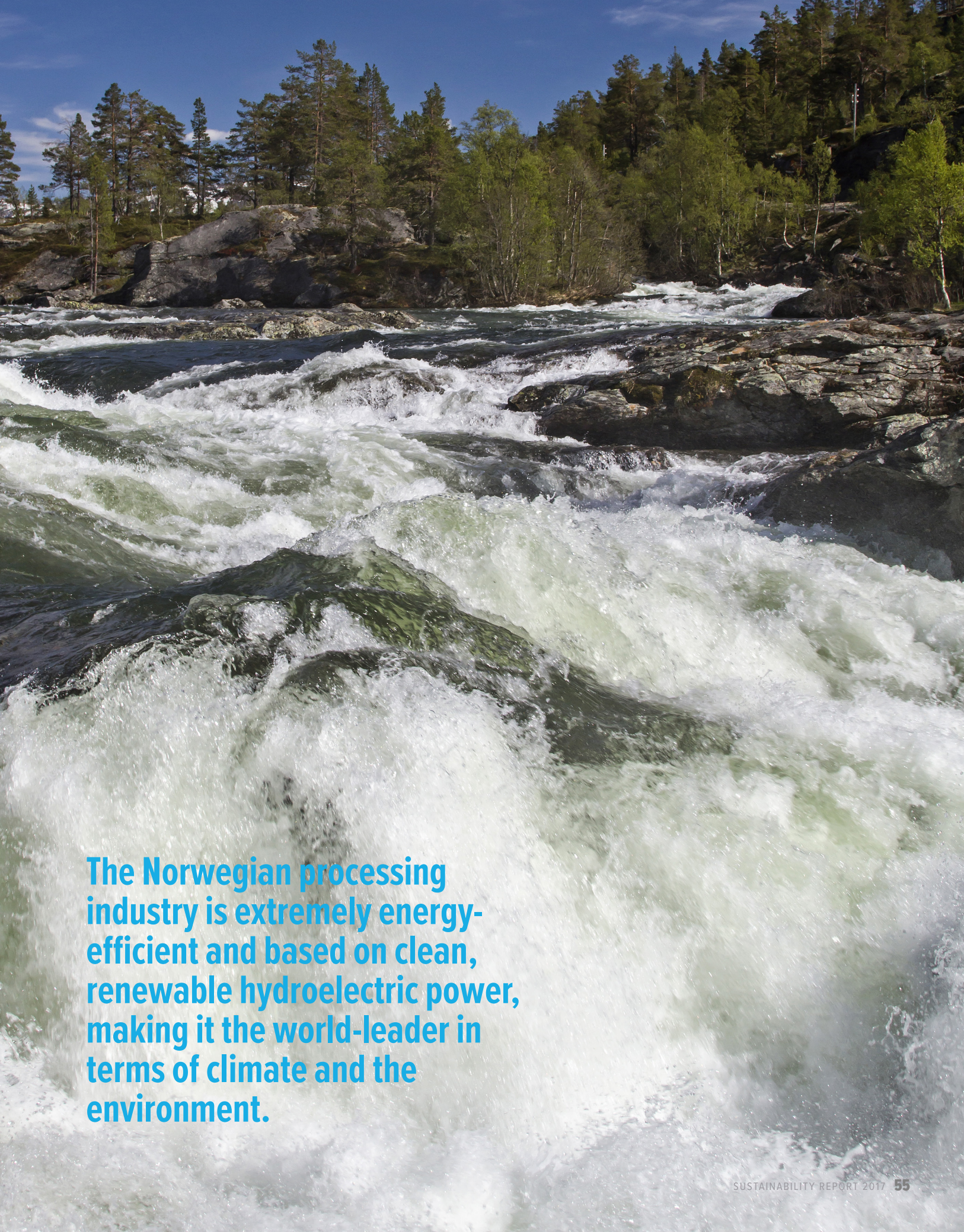
Norwegian research – a decisive area of expertise in a global context

The processing industry is an expertise-driven sector that has responded to continuous and increasing global competition with continuous efficiency-improvements. The result is that the Norwegian processing industry, together with a number of research environments and educational institutions, now represents a significant expertise resource – and one that will prove entirely decisive in developments to come.

We have to strengthen our position in the low-emission society

In the low-emission society of the future, there will be an increased demand for products with a small carbon footprint. This is also the case for products which contribute to reduced energy consumption, products used in energy production and storage installations, and products based on renewable raw materials.

The Norwegian processing industry is currently extremely well placed, with everything required to further strengthen its position in the low-emission society – as long as we have an innovative and wealth-creating Norwegian processing industry before 2050. The aim of the road map is to show us how to achieve this. It should describe technological opportunities and barriers, and which tools and general conditions are required if we are to succeed.



The Norwegian processing industry is extremely energy-efficient and based on clean, renewable hydroelectric power, making it the world-leader in terms of climate and the environment.

HR – ERAMET NORWAY

HANS HYLEN SOLBERG

Adviser, Sauda upper secondary school

INDUSTRY AND EDUCATION FORM VITAL PARTNERSHIP

In autumn 2017, Sauda upper secondary school took on a new regional development role as part of a partnership between local authorities, economic development agencies and key businesses in the Indre Ryfylke region.

The objective is to match training and education opportunities with the skills required in the workplace, enabling businesses to compete better in both the short and the long term. Social responsibility becomes a shared concern, since all the partners are in the same boat and are equally responsible for progress and development.

This strategic move has produced the following objectives:

- To provide skills-intensive businesses with relevant, in-demand skills
- To strengthen social cohesion through collaboration between schools and businesses
- To train and recruit local young people for important jobs in the community
- To ensure that young people stay in the area and find jobs after completing their education

COEXISTENCE AND SOCIAL RESPONSIBILITY

Business challenges society, and vice versa, to secure jobs and build communities. Coexistence promotes social responsibility for the benefit of everyone.

On 12 December 2017, Rogaland county council agreed to set up a pilot project on workplace and academic skills at Sauda upper secondary school.

This four-year educational programme combines vocational and academic subjects through weekly alternation between classroom- and workplace-based learning. It offers young people a unique development opportunity leading to both a vocational qualification and an academic certificate in the natural sciences.

This is also a unique opportunity for businesses to highlight their industry as a place to work while attracting well-qualified prospective employees. Eramet Norway Sauda and Norsk Stein, Europe's largest quarry business, have been instrumental in bringing this education option to Rogaland.

The major processing industries in the Indre Ryfylke region have taken on key roles in this future-oriented team effort. ●

APPRENTICES: ERAMET NORWAY'S FUTURE

Eramet Norway's apprentices are rejuvenating operations and providing the company with an excellent recruitment base.

The fact is that almost half the workforce at Eramet Norway will need to be replaced over the next decade, mainly because of people retiring. Apprentices are a priority for the company, and the number of apprentices in 2017 matched the record set in 2016. The recent recruits include Tonje Elise Bastesen Feirud, who is enjoying her work as an apprentice mechanic at the Herøya plant in Porsgrunn.

NO REGRETS

Tonje is an ambitious young woman who dreams of working offshore in the North Sea one day, unless she lands a permanent job at Eramet Norway. She enjoys being physically active at work, so industrial mechanic rather than process operator was the job for her.

"I love working with my hands, tinkering around and making things work," says Tonje. "My role models are three uncles who all work in the North Sea. When I gained an apprenticeship place at Eramet Norway Porsgrunn, I was pleasantly surprised by how nice the people and the working environment are."

The apprentice industrial mechanic is glad she wasn't put off by the stereotypical notion that this is a man's job.

"Boys will be boys. They have their own sense of humour," says Tonje with a smile. "But I'm not going to let that stand in the way of my dream. The lads here now realise they're dealing with someone who gives as good as she gets."

When her apprenticeship ends in 2019, Tonje will start her second round of military service. She is hoping to join the navy, but whatever happens, she will complete her college programme and then have the opportunity to train as an engineer. A permanent job at Eramet Norway is an enticing prospect, though, so Tonje is taking things six months at a time.

"To any girl who's unsure whether she dares enter a male-dominated profession, I'd simply say: Just do it!

Then, later on, you won't have to regret not having done it. It's fun!" ●

61
apprentices at Eramet Norway in 2017

LIFELONG LEARNING AT WORK

Looking to the future, Eramet Norway took several initiatives to boost skills levels across the company in 2017. Everyone is involved – apprentices, process operators and managers.

Last year marked a turning point for Eramet Norway as an organisation. With the launch of a tailor-made development course for process operators and a management development programme, we have embarked on the task of identifying and plugging skills gaps among our workforce.

One of Eramet Norway's strategic objectives is to be a learning organisation, and skills development is a key part of that process.

"Our aim is that these new skills development initiatives will give our colleagues greater independence in the workplace and facilitate effective teamwork," says Marianne Synnes Kaasa, HR director. "We hope the programmes will provide individual colleagues with fresh impetus, new ideas and a better network for sharing know-how within Eramet."

LEARNING AT WORK

At Eramet Norway Porsgrunn, process operators helped to design the Learning at Work pilot project. Among those who provided input were several apprentices, who contributed up-to-date knowledge of current health and safety requirements. Ivar Røstberg, a process operator for 34 years, supervised one of the apprentices involved in developing the pilot project.

"To begin with, Learning at Work met with a lot of scepticism," says Røstberg. "But, before long, participants were telling us that they had in fact learned something, and that it was both interesting and useful."

The objective of Learning at Work is to make process operators think about how they actually perform their work, with a constant focus on relevant health and safety issues.

"For the project to have an impact, it was important not to make operators feel that they were having to retake their certificate," Røstberg adds. "Our process operators are skilled industrial workers who know their job inside out, and this is simply a matter of keeping up with developments."

Learning at Work consists of several modules. One covers general knowledge of the business, another covers knowledge of a specific area (such as each furnace), and a third covers the various roles on a shift. A workbook has been produced for participants to make notes in and use as a starting point for the learning process. When operators feel they have completed their modules, they attend an interview with an examiner who asks them questions about the course content, giving them an opportunity to explain and demonstrate what they have learned. The Learning at Work programme is to be rolled out to Sauda and Kvinesdal in 2018.

MANAGEMENT DEVELOPMENT PROGRAMME

Good management is key to developing the organisation, increasing productivity and driving change. Going forward, Eramet Norway is committed to more systematic skills development at all levels. This includes a management development programme with annual managers' meetings, courses, workshops and guidance sessions.

Ivar Røstberg, a process operator for 34 years, supervised one of the apprentices involved in developing the pilot project.

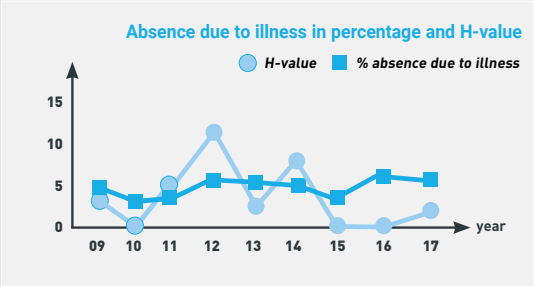
"The idea is that, as managers, we should be equipped with tools that will help us in our day-to-day work and make the job of managing easier,"

says Marianne Synnes Kaasa, HR director. She mentions workshops on a variety of relevant topics including planning, skills development, metallurgy for managers, personal efficiency and self-management, purchasing and IT.

"The participants are enthusiastic and well prepared," she adds. "This programme is something that managers wanted. The managers' meeting and the various monthly workshops scored well in evaluations."

SAUDA

Injury figures H1 and absence due to illness

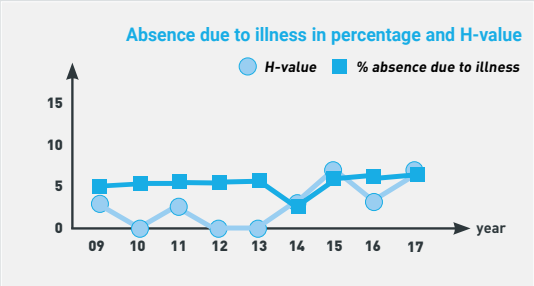


HES FIGURES

CATEGORY	2016	2017
Absence due to illness	6.1 %	5.3 %
Injuries w/ absence	0	3*
Injury figures H1 (H-figures)	0	9.2
Undesirable incidents - environmental	226	139
Complaints from neighbours	51	47
Violation of discharge permit	0	0

PORSGRUNN

Injury figures H1 and absence due to illness

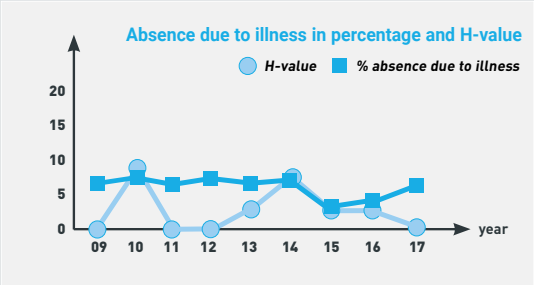


HES FIGURES

CATEGORY	2016	2017
Absence due to illness	5.5 %	6.0 %
Injuries w/ absence	1	3
Injury figures H1 (H-figures)	3.3	6.9
Undesirable incidents - environmental	121	54
Complaints from neighbours	24	23
Violation of discharge permit	0	1

KVINESDAL

Injury figures H1 and absence due to illness



HES FIGURES

CATEGORY	2016	2017
Absence due to illness	4.5 %	6.2 %
Injuries w/ absence	1*	0
Injury figures H1 (H-figures)	2.2	0
Undesirable incidents - environmental	24	48
Complaints from neighbours	0	1
Violation of discharge permit	0	1

** External workers*

The company´s greatest asset is its trained and motivated workforce.

ERAMET NORWAY HES-POLICY

OBJECTIVE

At Eramet Norway, we seek to conduct our business in such a way as to minimize potential harm to health, the environment and safety throughout the value chain. Metals, materials and other products are to be manufactured using resource-efficient processes with due regard for health, the environment and safety. As an environmentally conscientious company, we are committed to maintaining a safe working environment that protects our employees, facilities and assets.
The twin goals of preventing environmental damage and continuously improving our performance on health, the environment and safety underpin all our activities.

PRIORITIZATION

Health-, environment- and safety-related activities are to be integrated into all aspects of our operations. Our chief concern is to protect our employees and other stakeholders from workplace injuries and adverse health effects.
We are committed to complying with all applicable statutory and regulatory requirements, and with all codes of practice endorsed by the company.
Environmental and safety aspects will be a key consideration when we make decisions on capital expenditure, operating methods and changes.

RESPONSIBILITY

Managers at all levels have overall responsibility for health, the environment and safety in their respective areas. They are responsible for planning, organizing and training, for implementing health, environmental and safety procedures, and for ensuring that practices comply with statutory and regulatory requirements.
Managers are to set specific targets for improvement and seek the cooperation of employees in achieving those targets. All managers and employees have a shared responsibility to create a safe workplace, to protect the environment, and to protect the company's resources and equipment. All employees are personally responsible for protecting themselves and for safely performing their duties according to established

IMPROVEMENT

Health, the environment and safety are integral parts of Eramet Norway's management system.
A continuous improvement program is to be put in place, based on careful evaluation of the potential for undesirable incidents and suggested improvements. Reporting of undesirable incidents is to be a priority, as the starting point for implementing corrective and preventive measures.

PREVENTION

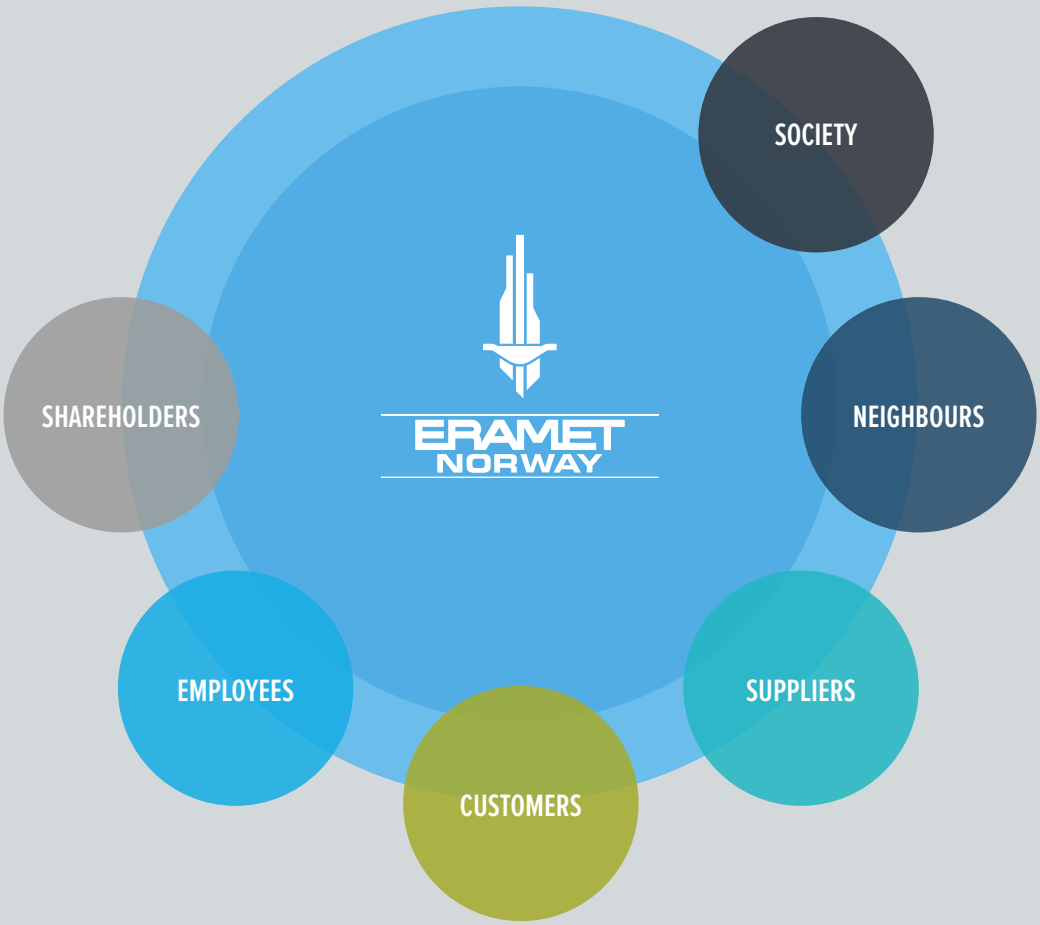
Health, environmental and safety procedures and practices, and any changes to these, are to be based on a thorough risk assessment. Operational plans and capital projects will likewise be subject to an assessment of the health, environmental and safety risks. Potential hazards are to be identified and assessed. Undesirable incidents such as near mishaps, accidents, injuries to health and environmental damage are to be recorded and investigated to determine the root cause and prevent recurrence.

FOLLOW-UP

To ensure compliance with statutory and regulatory requirements, and respect for Eramet's own environmental goals, policies and guidelines, a system must be in place for ongoing reporting, record keeping and review. Eramet Norway is to publish an annual health, environment and safety report. ●

As an environmentally conscientious company, we are committed to maintaining a safe working environment that protects our employees, facilities and assets.

SUCCESS FOUNDED ON TRUST



Supporting the local community

Eramet Norway supports clubs, organizations, cultural activities and individual events at each of its production locations. It is important that the local community around our company continues to provide opportunities for cultural and leisure activities.

Customers making ever-greater demands

Sustainable products and processes are also increasingly being discussed in the context of our customer relations. As a leading supplier of manganese alloys, we work actively in order to satisfy our customers' requirements, as set out in their overall policies, specifications of requirements and guidelines. Regular audits are also conducted together with our main customers.

Collaborating for knowledge

Through our membership of forums such as Grenland Industrial Cluster, the Eyde network and EnergiRike, we are committed to sharing knowledge among regulatory authorities, politicians, centres of expertise and our own industry on major issues of mutual concern.

Collaborating with Bellona

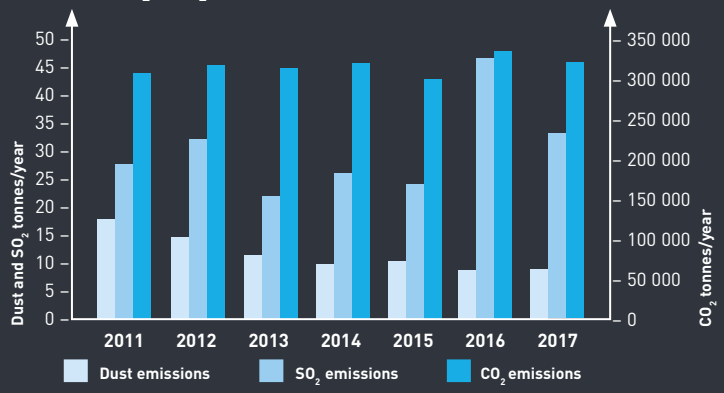
Eramet Norway and the Bellona environmental foundation have instituted a formalised collaboration, the aim of which is to make use of each other's core skills in order to improve society's environmental results.

Collaborating with the industry

Through the Norwegian Ferroalloy Producers Research Association (FFF), Eramet Norway has played a role in a number of important collaboration projects between the industry, Sintef and the Norwegian University of Science and Technology (NTNU).

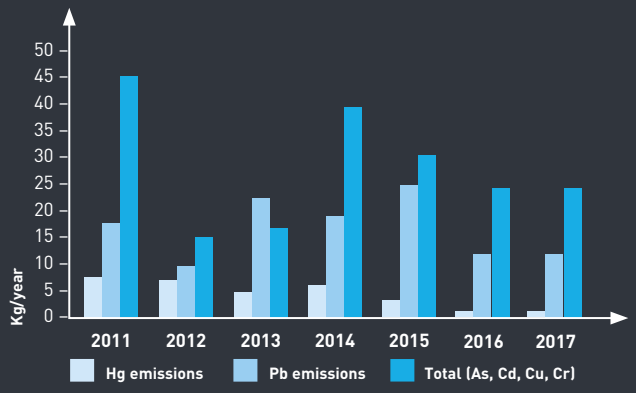
Since 2001 we have invested almost half a billion kroner in developing and installing new, environment-friendly technology.

DUST, SO_2, CO_2 emissions to the air 2011-2017



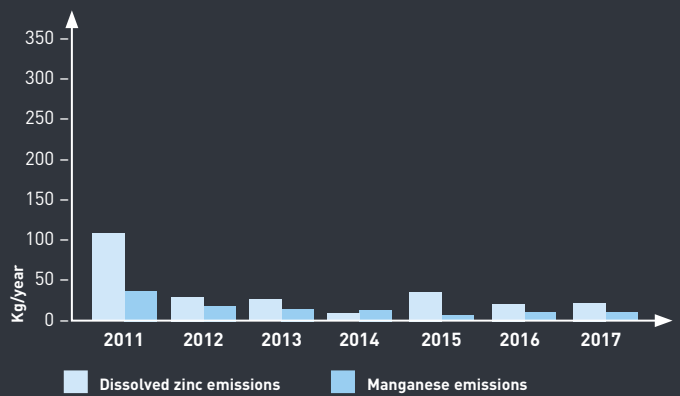
Emission limits:
Dust = 35 tonnes/year SO_2 = 50 tonnes/year

Hg/Pb/Total (As, Cd, Cu, Cr) emissions to the air 2011-2017



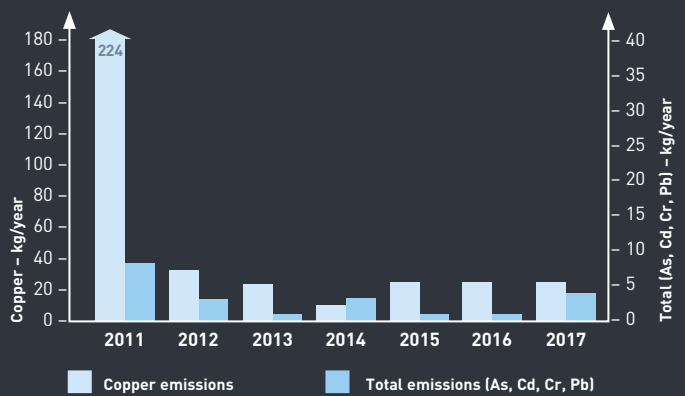
Emission limits:
Hg = 36 kg/year Pb = 100 kg/year Total (As, Cd, Cu, Cr) = 50 kg/year

ZINC/MANGANESE emissions to Saudafjorden 2011-2017*



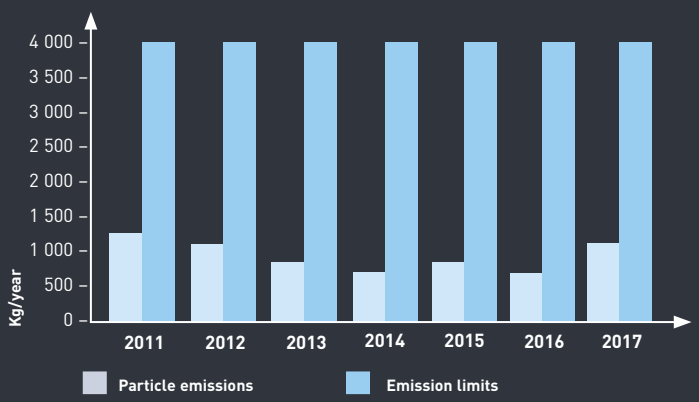
Emission limits: Dissolved zinc = 400 kg/year Manganese = 400 kg/year

COPPER/TOTAL (As, Cd, Cr, Pb) emissions to Saudafjorden 2011-2017*

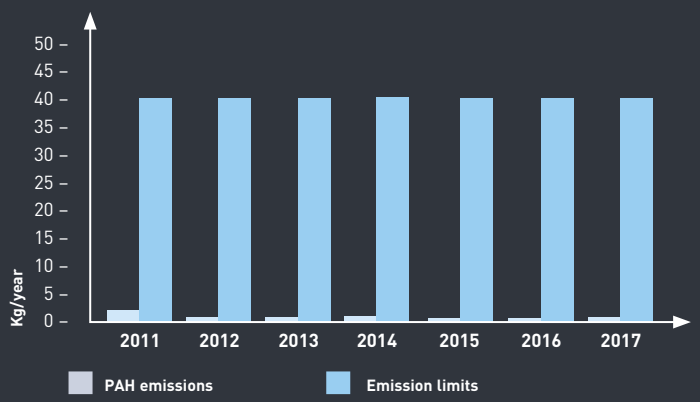


Emission limits: Copper = 150 kg/year Total (As, Cd, Cr, Pb) = 20 kg/year

PARTICLES emissions to Saudafjorden 2011-2017*



PAH emissions to Saudafjorden 2011-2017*



**Emissions from purifying plants.*

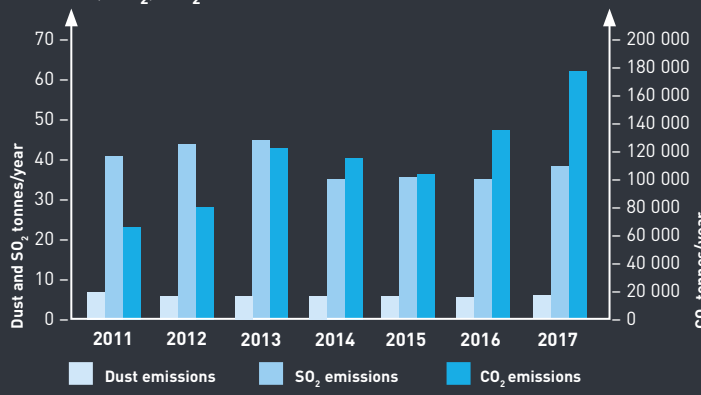
Waste

CATEGORY	2017	2016
Slag	0 tonn	0 tonn
Sludge and dust (landfill)	3 338 tonn	2 030 tonn
Residual waste	116 tonn	107 tonn
Metal waste	301 tonn	396 tonn
Special waste	72,9 tonn	77 tonn

CATEGORY	2017	2016
Paper and cardboard	8.86 tonn	7.5 tonn
Wood waste	193 tonn	141 tonn
Plastic	3.1 tonn	3.9 tonn
Asphalt	0 tonn	0 tonn

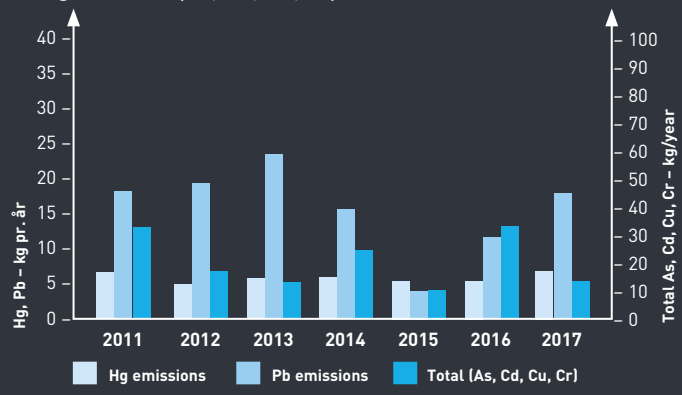
ERAMET NORWAY PORSGRUNN

DUST, SO_2, CO_2 emissions to the air 2011-2017



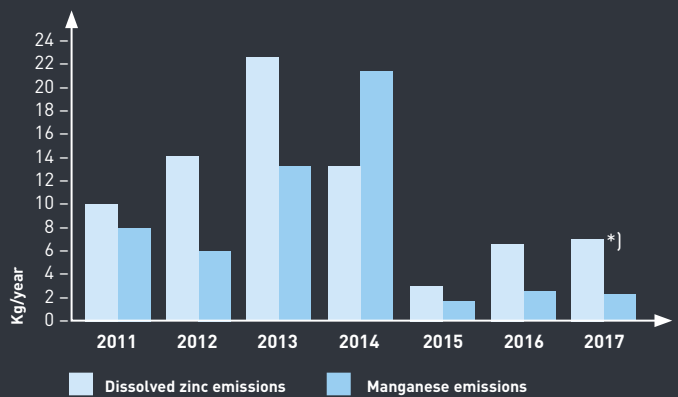
Emission limits:
Dust = 35 tonnes/year SO_2 = 50 tonnes/year

Hg/Pb/Total (As, Cd, Cu, Cr) emissions to the air 2011-2017



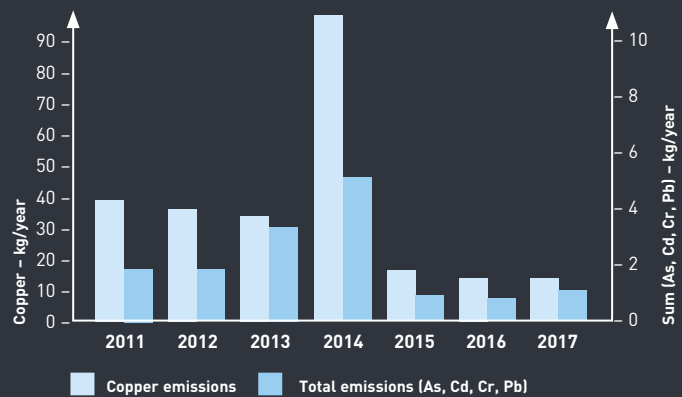
Emission limits:
Hg = 15 kg/year Pb = 150 kg/year Total (As, Cd, Cu, Cr) = 50 kg/year

ZINK/MANGANESE emissions to Frierfjorden 2011-2017*



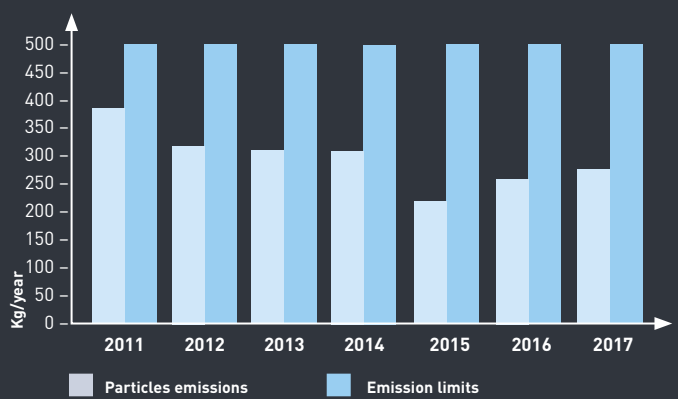
Emission limits: Dissolved zinc = 50 kg/year Manganese = 50 kg/year
*) Zinc total emissions is reported from 2017.

COPPER/TOTAL (As, Cd, Cr, Pb) emissions to Frierfjorden 2011-2017*

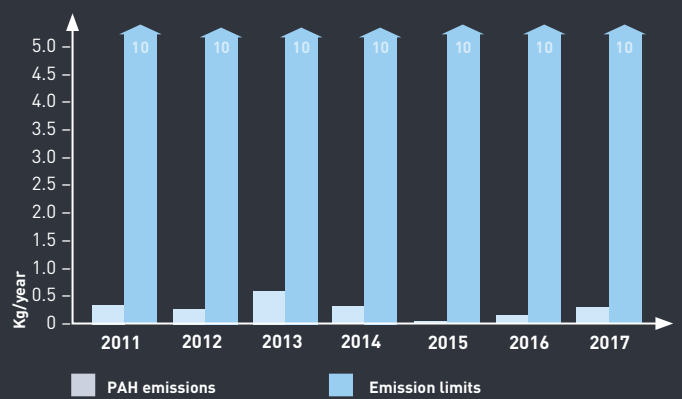


Emission limits: Copper = 100 kg/year Total (As, Cd, Cr, Pb) = 10 kg/year

PARTICLES emissions to Frierfjorden 2011-2017*



PAH emissions to Frierfjorden 2011-2017*



**Emissions from purifying plants.*

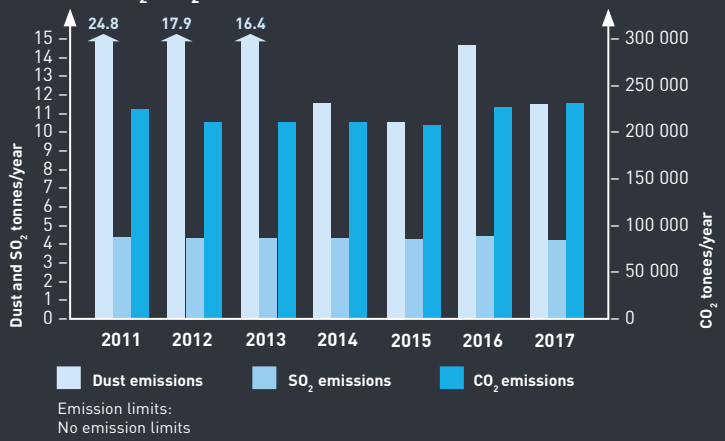
Waste

CATEGORY	2017	2016
Slag	87 687 tonnes	89 913 tonnes
Sludge and dust (landfill)	6 029 tonnes	5 203 tonnes
Residual waste	148 tonnes	115 tonnes
Metal waste	120 tonnes	158 tonnes

CATEGORY	2017	2016
Special waste	65.4 tonnes	44.6 tonnes
Paper and cardboard	3.8 tonnes	4 tonnes
Wood waste	142 tonnes	152 tonnes
Mixed rubber waste	20.2 tonnes	23.5 tonnes

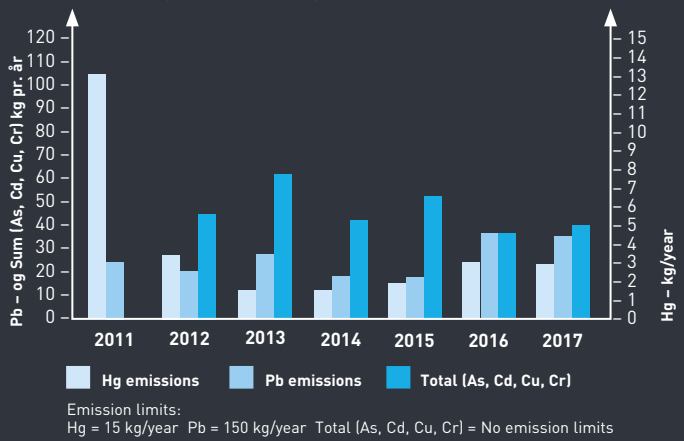
ERAMET NORWAY KVINESDAL

STØV, SO_2, CO_2 emissions to the air 2011-2017



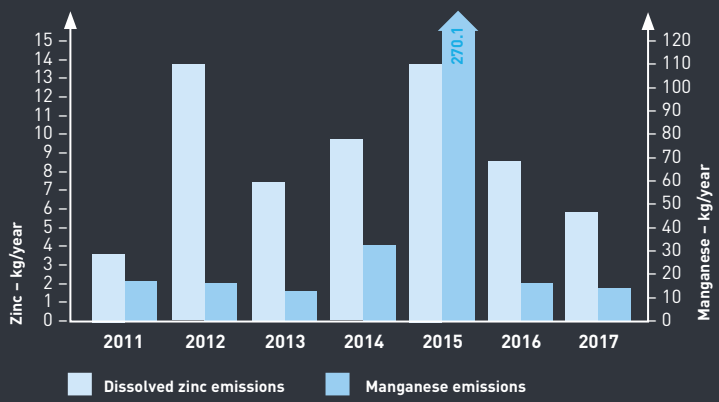
Emission limits:
No emission limits

Hg/Pb/Total (As, Cd, Cu, Cr) emissions to the air 2011-2017



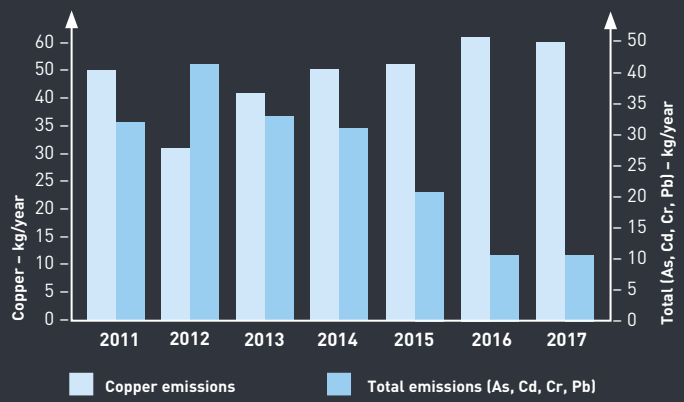
Emission limits:
Hg = 15 kg/year Pb = 150 kg/year Total (As, Cd, Cu, Cr) = No emission limits

ZINK/MANGANESE emissions to Fedafjorden 2011-2017*



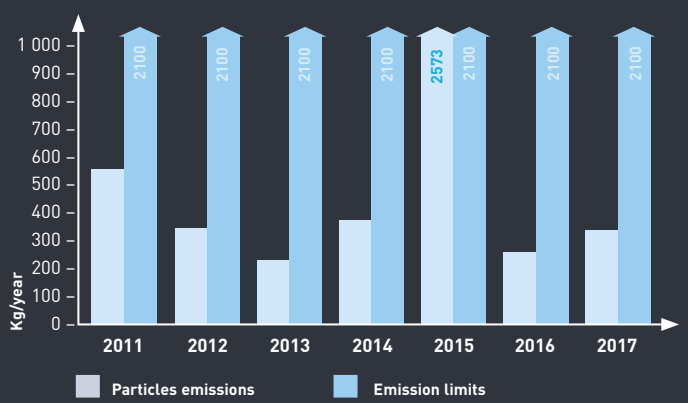
Emission limits: Dissolved zinc = 240 kg/year Manganese = 420 kg/year

COPPER/TOTAL (As, Cd, Cr, Pb) emissions to Fedafjorden 2011-2017*

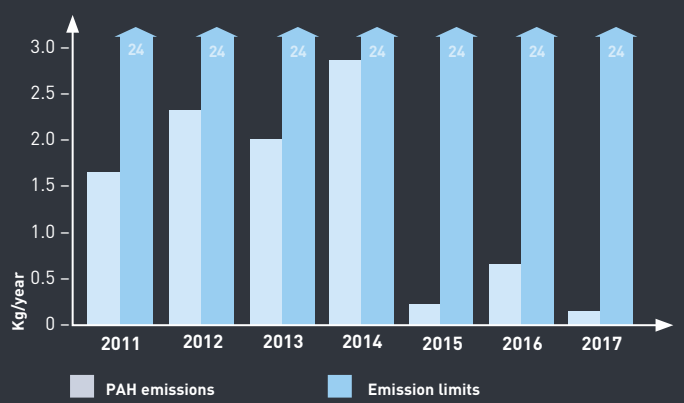


Emission limits: No emission limits

PARTICLES emissions to Fedafjorden 2011-2017*



PAH emissions to Fedafjorden 2011-2017*

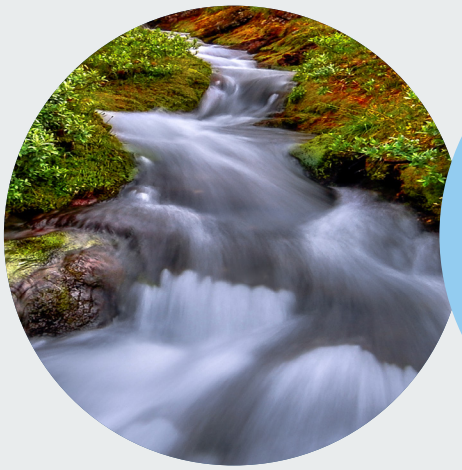


**Emissions from purifying plants.*

Waste

CATEGORY	2017	2016
Slag	221 816 tonnes	214 856 tonnes
Sludge and dust (landfill)	26 446 tonnes	32 531 tonnes
Residual waste	92.2 tonnes	111.16 tonnes
Metal waste	92.7 tonnes	110 tonnes

CATEGORY	2017	2016
Special waste	83 947 kg	37 160 kg
Paper and cardboard	2 061 kg	7 200 kg
Wood waste	35 300 kg	38 500 kg
Plastic	4 752 kg	4 500 kg



VALUES CREATED BY WATER

ENVIRONMENTAL INCOME 2017

Environmental income from sale of CO gas to Yara's ammonia factory at Herøya in Porsgrunn, and sales of manganese dust and sale of electrical energy at Kvinesdal.

16.5M NOK
SALES OF CO-GAS TO YARA

129.5M NOK
SALES OF MANGANESE DUST

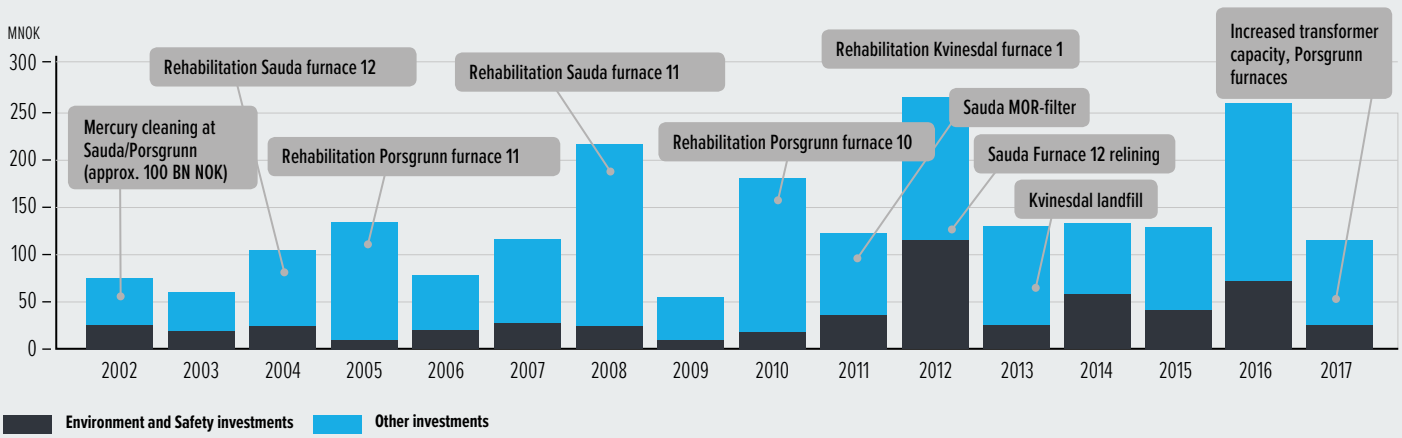
34.5M NOK
SALE OF ELECTRICAL ENERGY IN KVINESDAL

INVESTMENTS 2006–2017

Yearly investments in M NOK for Porsgrunn and Sauda during the period 2006-2017, and Kvinesdal for the period 2010-2017.

2 PLANTS (PORSGRUNN, SAUDA)					3 PLANTS (PORSGRUNN, SAUDA, KVINESDAL)									
Year:	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	SUM*	
Environment and Safety investm.	24	27	25	11	18	43	113	37	55	45	67	24	**693**	29 %
Other investments	61	86	192	40	166	81	144	103	86	92	187	94	**1685**	71 %
TOTAL INVESTMENTS	**86**	**113**	**217**	**51**	**184**	**123**	**257**	**140**	**141**	**137**	**254**	**115**	**2378**	100 %

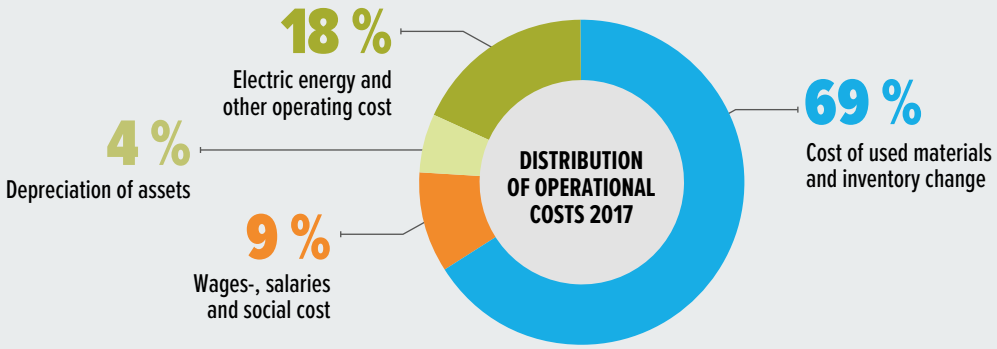
**) The total figure includes from year 2000.*



PROFIT & LOSS STATEMENT FOR 2016 AND 2017

Figures for the Sauda, Porsgrunn and Kvinesdal plants in M NOK.

	Last year 2017			Previous year 2016			Change	%
GROSS INCOME	**7 156**			**4 461**			**2 695**	**60 %**
Cost of used materials and inventory change	-3 463		69 %	-2 422		65 %	-1 041	-43 %
Wages-, salaries and social cost	-440		9 %	-267		7 %	-172	-65 %
Depreciation of assets	-220		4 %	-214		6 %	-6	-3 %
Electric energy and other operating cost	-908	-5 030	18 %	-835	-3 738	22 %	-72	-9 %
OPERATING RESULTS		**2 125**			**722**		**1 403**	**194 %**
Interest-/financial cost		-168			-153		-15	-10 %
Corporate taxes		-467			-139		-329	-237 %
NET RESULT	**1 490**			**431**			**1 059**	**246 %**



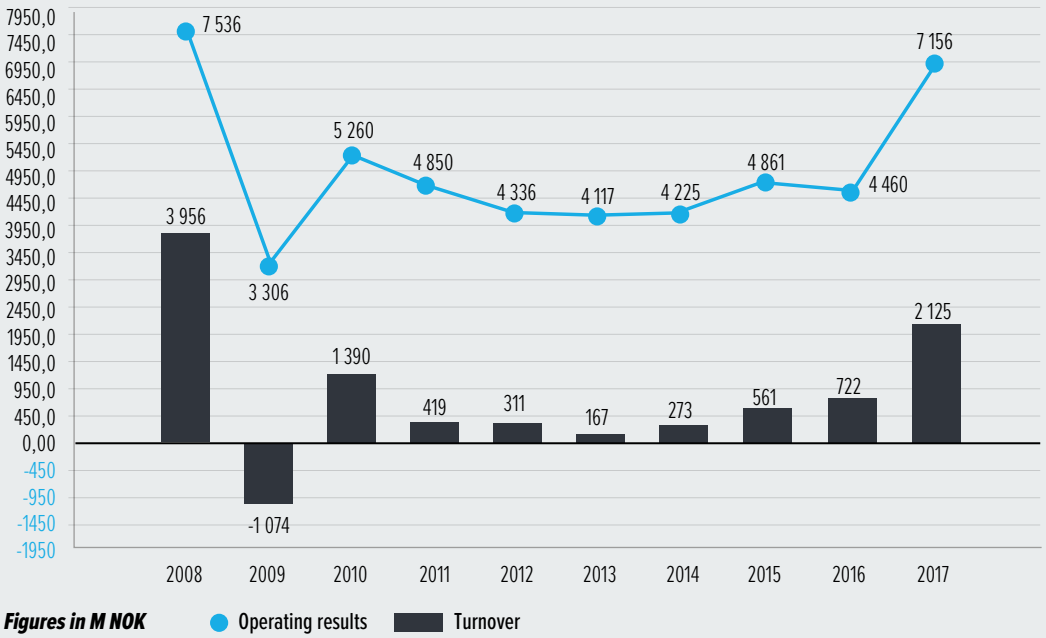
TURNOVER AND OPERATING RESULT

History of the Sauda, Porsgrunn and Kvinesdal plants. Figures are in M NOK.

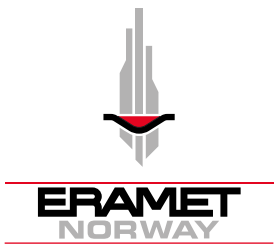
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Operational result	3 956	-1 074	1 390	419	311	166	273	560	722	2 125
Turnover	7 536	3 306	5 260	4 850	4 336	4 117	4 224	4 861	4 460	7 156
Operating margin	**52.5 %**	**-32.5 %**	**26.4 %**	**8.6 %**	**7.2 %**	**4.0 %**	**6.5 %**	**11.5 %**	**16.2 %**	**29.7 %**

7156 M NOK
OPERATING RESULTS 2017

2125 M NOK
TURNOVER 2017



Tenk Kommunikasjon // tenkkom.no // Foto: Benjamin Nordhagen, Max Emanuelson, ERAMET Research, DSFOTO, Tor Egil Hoftun Kvæstad // Printed on 100% recycled paper.



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PORSGRUNN
PO. Box 82, NO–3901 Porsgrunn.
Tel.: 35 56 18 00, fax: 35 55 36 10

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Øyesletta 61, NO–4484 Øyestranda.
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ISO 9001/ISO 14001/ISO 50001
SERTIFISERT BEDRIFT