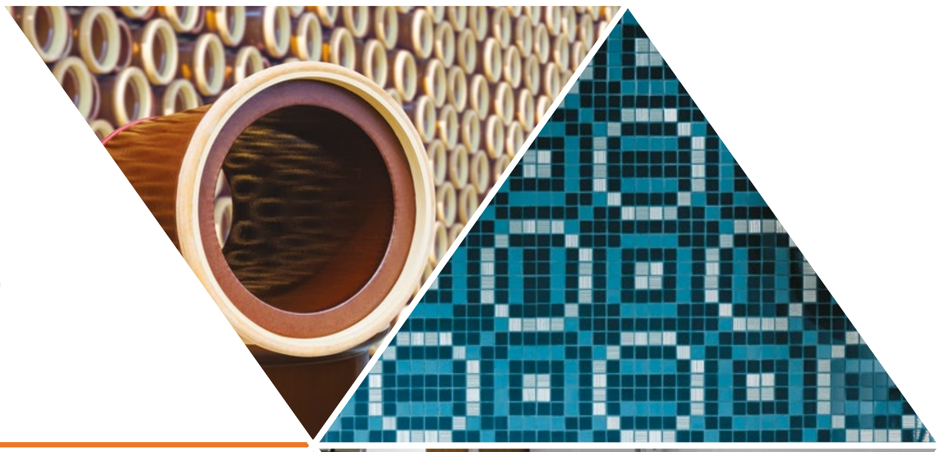


CERAMIC ROADMAP TO 2050

CONTINUING OUR **PATH** TOWARDS **CLIMATE NEUTRALITY**

Cerame-Unie
The European Ceramic Industry Association

Table of contents

FOR THE WELL-BEING OF A RESILIENT, CLIMATE NEUTRAL EUROPE

Introduction

For thousands of years, ceramics have been used in a wide range of applications, and today, the European ceramic industry is a global leader in both production and innovation.

History and modernity, side by side

Wherever you go in Europe, from Gmunden to Faenza, Delft, Castelló de la Plana, Bolesławiec, Höhr-Grenzhausen, Limoges, Sassuolo, Selb or Stoke-on-Trent, you will find the rich heritage of the European ceramic industry.

Stopping (using your car's ceramic brakes) in even the smallest village, you will discover the versatility of ceramic products: from bricks to roof tiles, sanitaryware, tableware and ornamental ware, clay drainage pipes or wall and floor tiles, expanded clay; not to mention the industrial and hi-tech applications such as refractories and technical ceramics.

For thousands of years, ceramics have been used in a wide range of applications, and today, the European ceramic industry is a global leader in both production and innovation.

Since Roman times, clay has been extracted from the ground across Europe to be turned into everything from terracotta tiles to toilets.

The ceramic industry in Europe today is building on thousands of years of skill, tradition, expertise and flair – delivering high-quality, versatile products that play a critical role in our homes, businesses and industries.

This proud history is what makes the European ceramic industry so deeply rooted in Europe's economy, society and culture.

Ceramics – a continental champion

The European ceramic industry has a total EU turnover of €26 billion, and more than a third of production volume is exported outside the EU. The industry provides more than 200,000 direct and 400,000 indirect jobs, across every country in Europe.

Ceramics are integral to many other industries, which is why our sector is at the heart of many manufacturing and R&D clusters across Europe – fostering knowledge and innovation.

Europe is the cradle of the ceramic industry worldwide, and still the point of reference for the highest quality, the most sophisticated manufacturing methods, the most sustainable production, and the most attractive design.

On a mission to reduce emissions

Ceramics are made from natural materials, but their production is energy-intensive and generates emissions. At all levels of production, the European industry is working together to reduce these emissions.

We have already come a long way. For example, the CO_2 emitted to produce the clay blocks for one square metre of an external wall has on average been reduced to approximately 50% between 1990 and 2020, and for one tonne of wall and floor tiles the energy used was reduced by 47%. Total CO_2 emissions in the ceramic industry in the EU fell by more than 45% since reaching a peak in the year 2000.

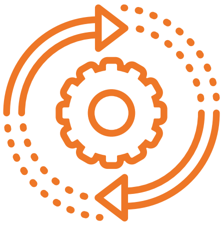
The use of ceramic materials can help save energy

Our carbon commitment covers not only the production processes of the European ceramic industry but impacts the many other sectors that rely on our products.

As the renovation and upgrading of residential and public buildings gathers pace, our sector is ideally placed to contribute to ensuring the highest standards of energy efficiency and the least possible energy leakage. A broad range of ceramic products, ranging from clay blocks with inherent insulating qualities to ventilated cavity walls and clay facades or roof tiles, all help make buildings more energy-efficient.

In energy-intensive industries, refractory products help contain energy where it is needed, minimising energy wastage.

Accelerating progress



Our industry is on a course towards decarbonisation, building on past achievements and leveraging innovation. The very nature of our production requires heat, and as we transform raw material into products, the fuel and process emissions generated will need to be further reduced, captured and sequestrated, reused, compensated for, or offset. Nevertheless, we are confident that, with the support of a robust EU policy framework, we can work together towards this common objective.

With strong backing from the EU institutions and Member States, the ceramic industry in Europe will continue to raise standards of innovation, social responsibility and environmental leadership.

The European ceramic industry is committed to working with the European Union institutions to lead the transition to a net zero-carbon economy within the coming decades.

Determined to decarbonise

Every industry has a role to play in making Europe environmentally sustainable for future generations. We are committed to continue down the decarbonisation road, guided by the ambitions of the European Green Deal.

Cerame-Unie, as the voice of the ceramic industry in Europe, is working on plans to progressively increase the efficiency, and rapidly decrease the environmental impact, of the sector's production. Our roadmap presents an ambitious vision for Europe to become a net-zero emitter by the middle of this century.

The European ceramic industry, because of its unique products that are essential to so many value chains, is a key component of Europe's decarbonisation ambition for 2050 and beyond. However, we cannot achieve our goals in isolation. Our industry is part of a broader industrial ecosystem that includes raw materials supply, energy sources, manufacturing sites and downstream users. All parts of the European economy, and indeed society, will need to work in unison to meet the ambitious goals we have set. Policymakers at European, national and local level have a key role to play to create the right conditions for change.

Sustainability is in our DNA

Cerame-Unie members take their role as corporate citizens seriously. Our top priority is to help our industry to flourish as an industrial standard bearer in Europe and throughout the world as a genuine export champion.

Sustainability is at the heart of everything we do as an industry.

- Environmental – constantly enhancing our resource efficiency while lowering our environmental impact.
- Social – providing good local jobs in mainly rural areas across Europe, and contributing to create healthier and affordable buildings.
- Economic – nurturing a competitive sector that fosters a modern, hi-tech economy and local value creation.

Sustainability is also a life-cycle concept. Secondary raw materials from our industry and other industries can be used, and ceramics can be recycled and reused, so the industry itself becomes more sustainable because it is preserving raw materials and subsequently limiting emissions associated with extraction.

Innovation – what we do best

At a time of transformation and uncertainty, the European ceramic industry's anticipation, versatility, and adaptability are among our greatest strengths.

Innovation is at the heart of everything we do. With over a third of the European ceramic industry's production being exported outside Europe, we are a window for the world to appreciate the expertise, production quality, creativity of design and vision on which our industry is built.

The way in which our producers across Europe have linked to universities and research institutes to form clusters of excellence is a primary driver of our innovative spirit.

Cerame-Unie is proud of our industry's hard-earned reputation as an ambassador of European quality in every step of the production process.

We are already infusing that innovative zest into Europe's net-zero carbon commitment, and we hope that – as already in so many other ways – our focus on environmental sustainability will set standards for the sector elsewhere in the world to adopt.

Committed to Europe from start to finish

The European ceramic industry provides key materials for many strategic sectors from construction to manufacturing, automotive and energy production. Accordingly, ceramics will play an essential role in delivering on the European Green Deal, and ensuring that it can be done while promoting the "open strategic autonomy" of the European Union.

While some other industries have moved manufacturing offshore, the European ceramic sector benefits from a robust European supply chain at every step, and is committed to remaining a strong and reliable contributor to the EU's "open strategic autonomy". European ceramic products are exported globally, but their supply chains are often local, creating fully integrated industrial clusters around Europe. Thus, the local ceramic production in Europe can help support the EU's self-reliance.

However, our industry still remains at high risk of relocation, also known as carbon leakage risk. A level playing field, supported by trade policy, is paramount to ensure the viability of the industry in Europe.

We are committed to strengthening and greening this supply chain throughout, reinforcing the industry's position as a leading player in reducing our environmental impact. This strong European identity is what distinguishes us as a socially and environmentally responsible industry. We want to ensure that our heritage of thousands of years of ceramic production and our innovative and competitive ecosystems in Europe continue to thrive, and that the communities where our members are based continue to benefit from our commitment to them.

In maintaining and strengthening the ceramic industry in Europe by ensuring a just transition and a level playing field, we look to the European Union institutions for political support and policy clarity, so we can remain a global leader in the context of Europe's net zero-carbon ambition.

Our industry is a flagship exporter in Europe, and a standard bearer of European quality, innovation and expertise. We want to keep it that way.

The European ceramic industry in numbers

30
Member countries
Pan-European perspective

80%
SMEs
Local jobs

€26bn
Production value
Motor for growth

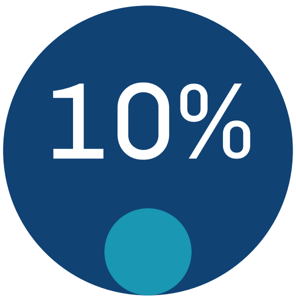
€5.1bn
Positive trade balance
Export champion

up to 30%
Production costs related to energy
Sensitive to energy prices

200,000
Direct jobs
Source of employment

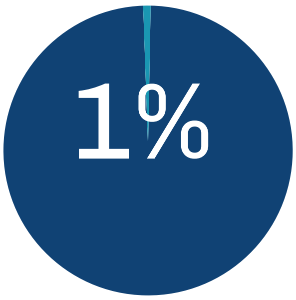
150 years
Average lifespan of a brick house
Durable products

Under ETS ceramics represent



of installations

but only

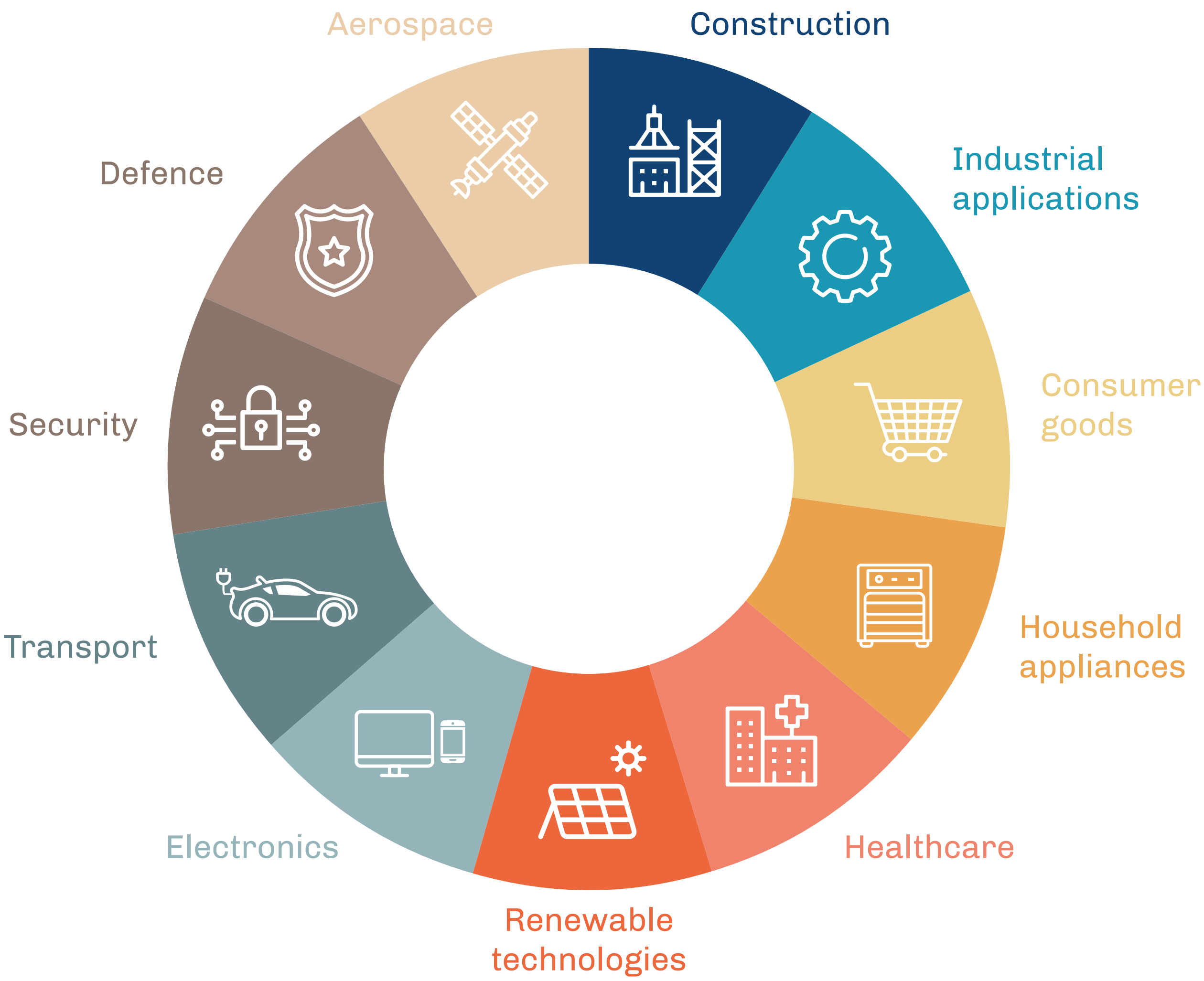


of industrial emissions

Many small installations, few emissions

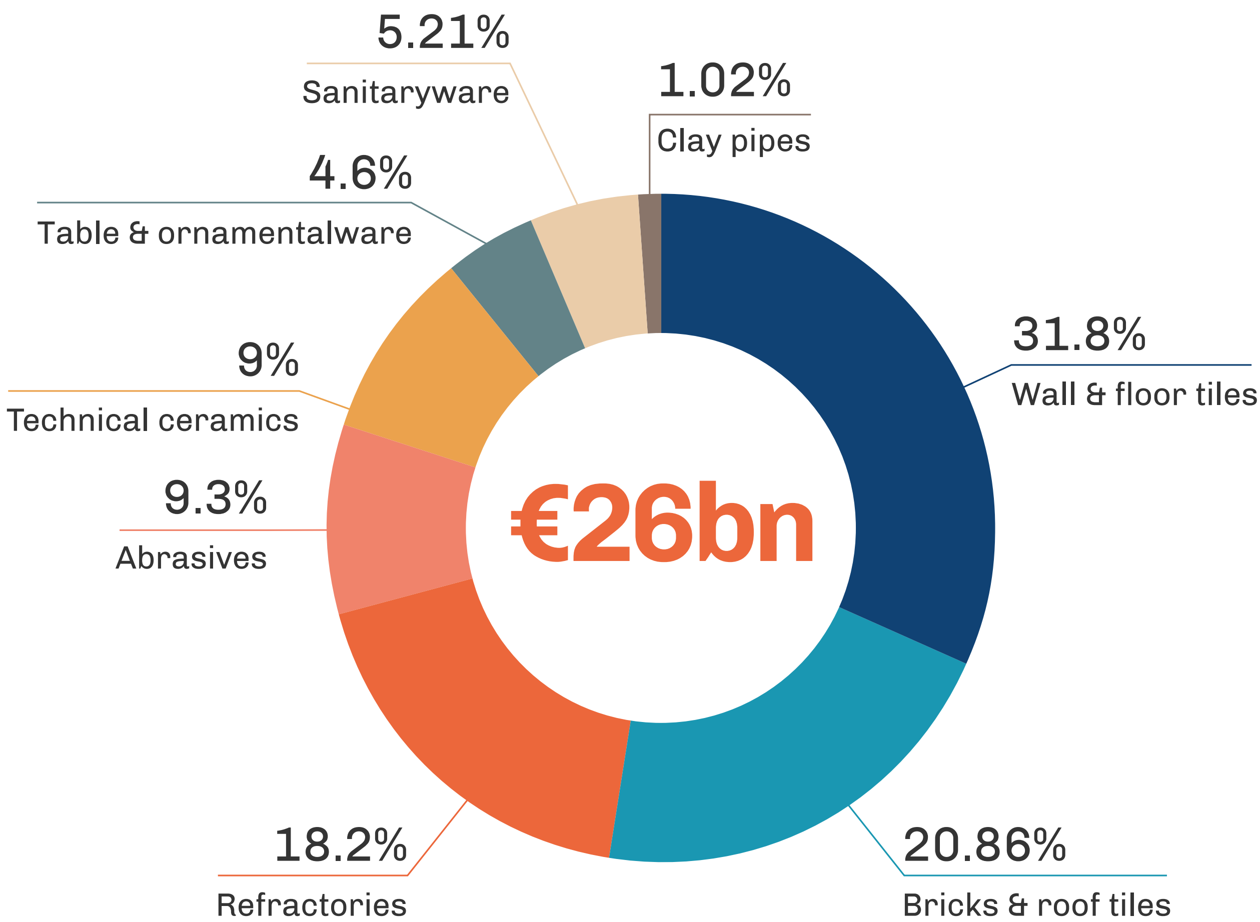
Source: Cerame-Unie

CERAMIC APPLICATIONS



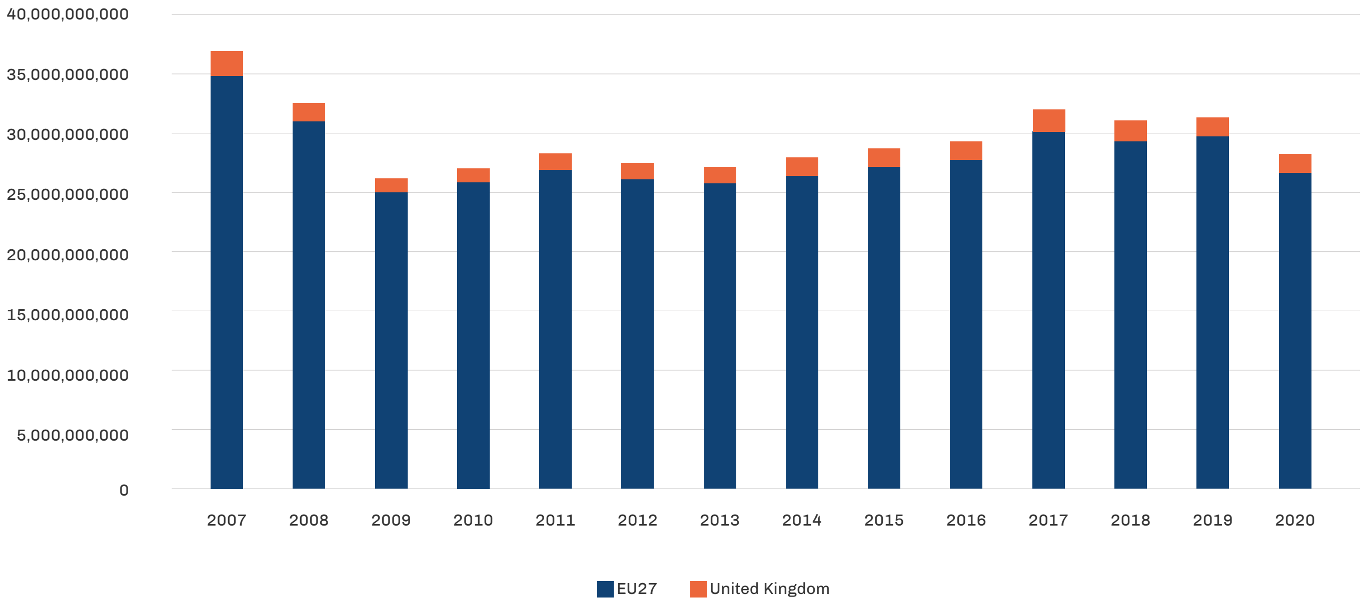
Source: Cerame-Unie

PRODUCTION VALUE



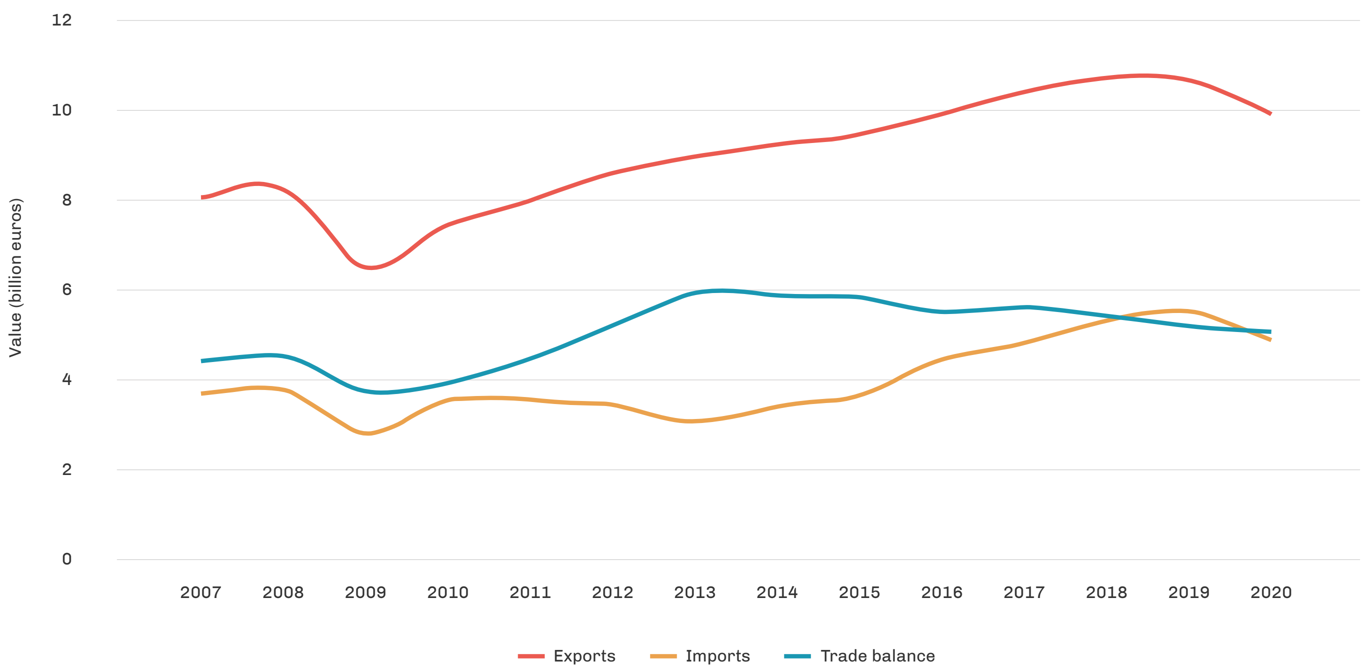
Source: Eurostat, 2020

PRODUCTION VALUE IN EU CERAMICS - EU27 & UK



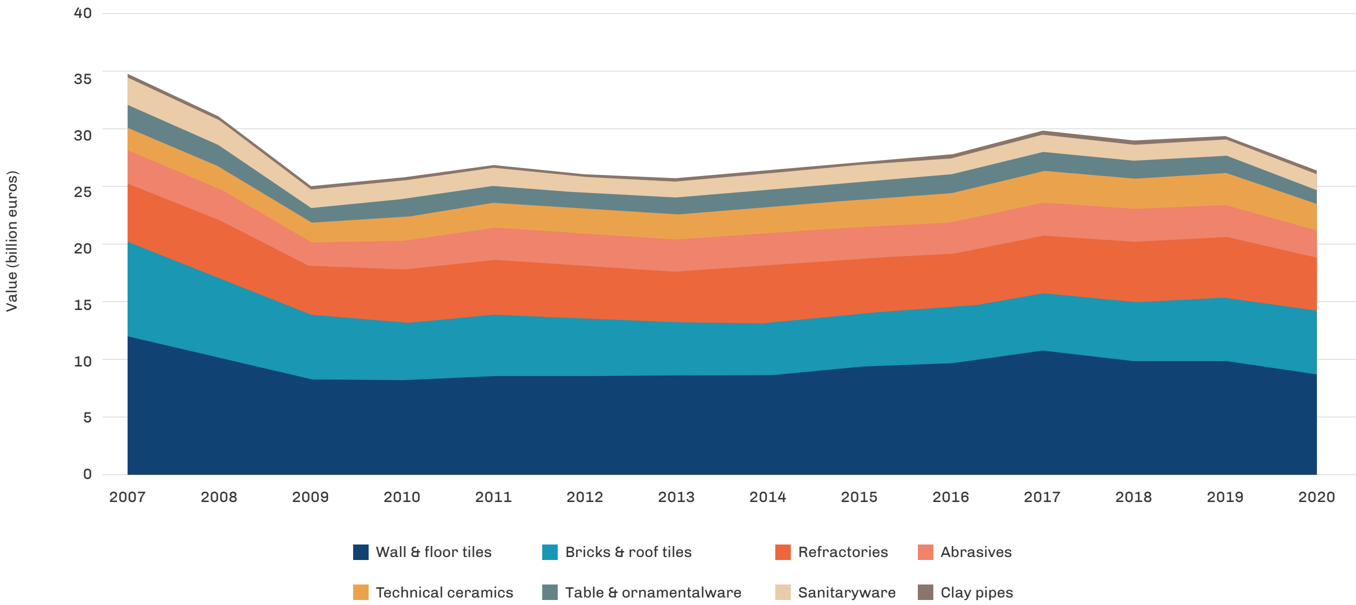
Source: Eurostat

TRADE BALANCE - EU27



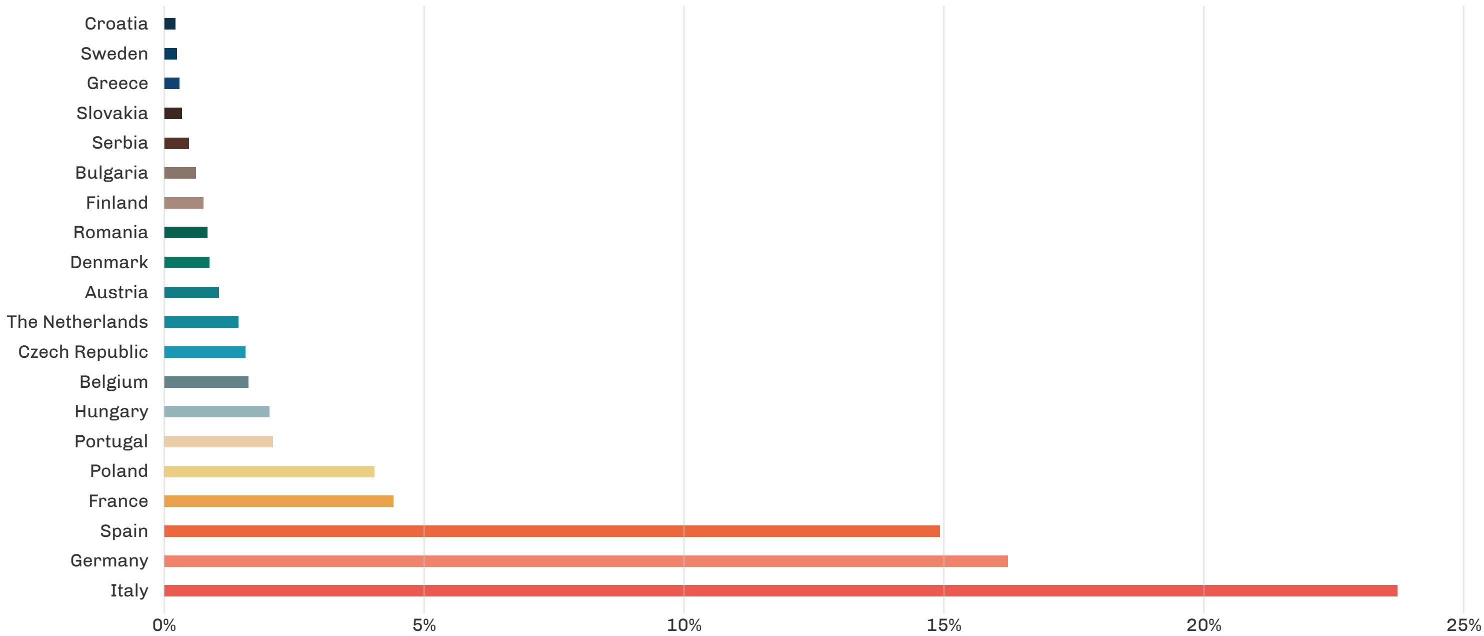
Source: Eurostat

PRODUCTION VALUE IN EU27 CERAMICS



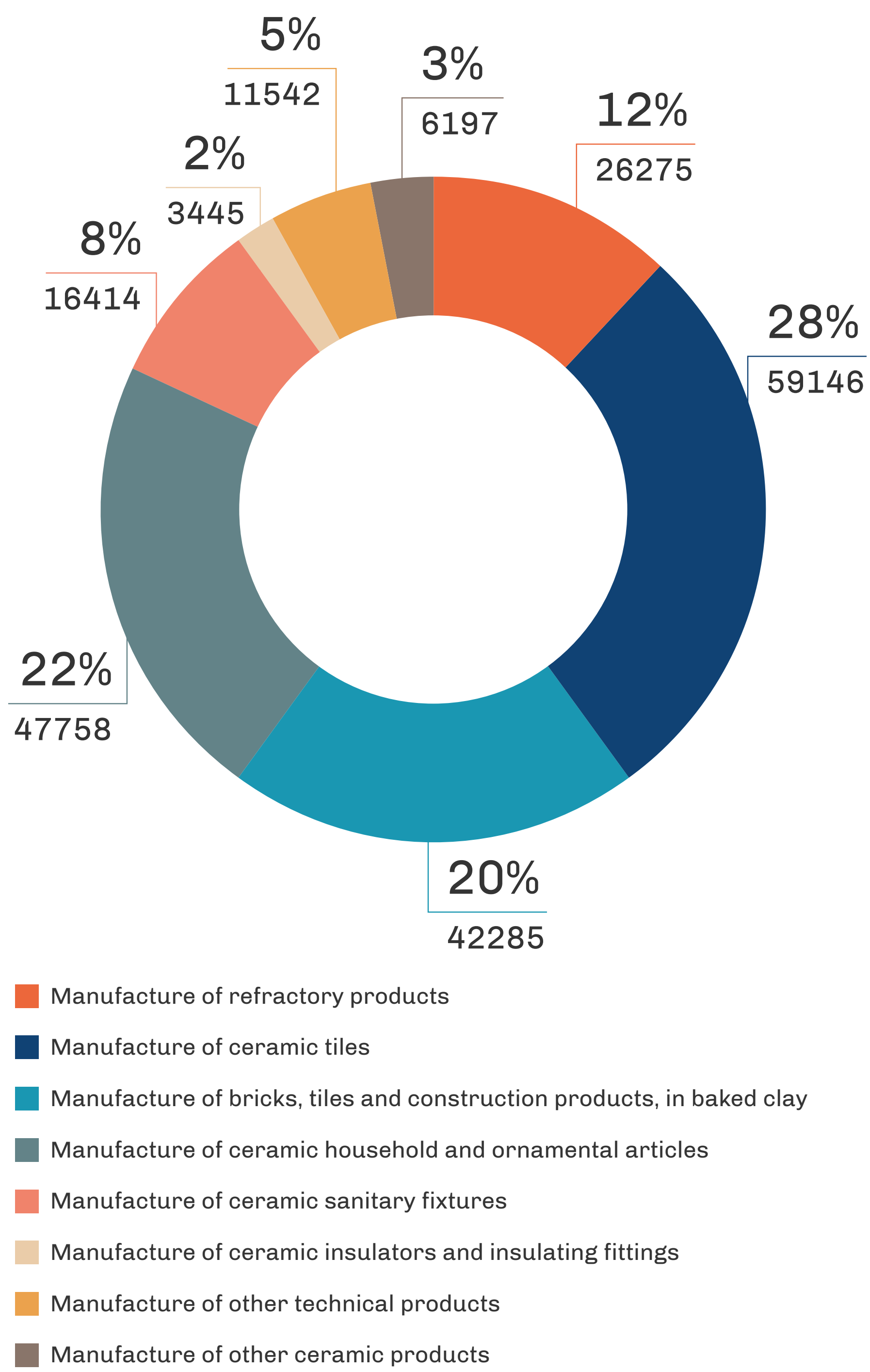
Source: Eurostat

PERCENTAGE OF PRODUCTION VALUE BY EUROPEAN COUNTRY (EU27) IN 2020



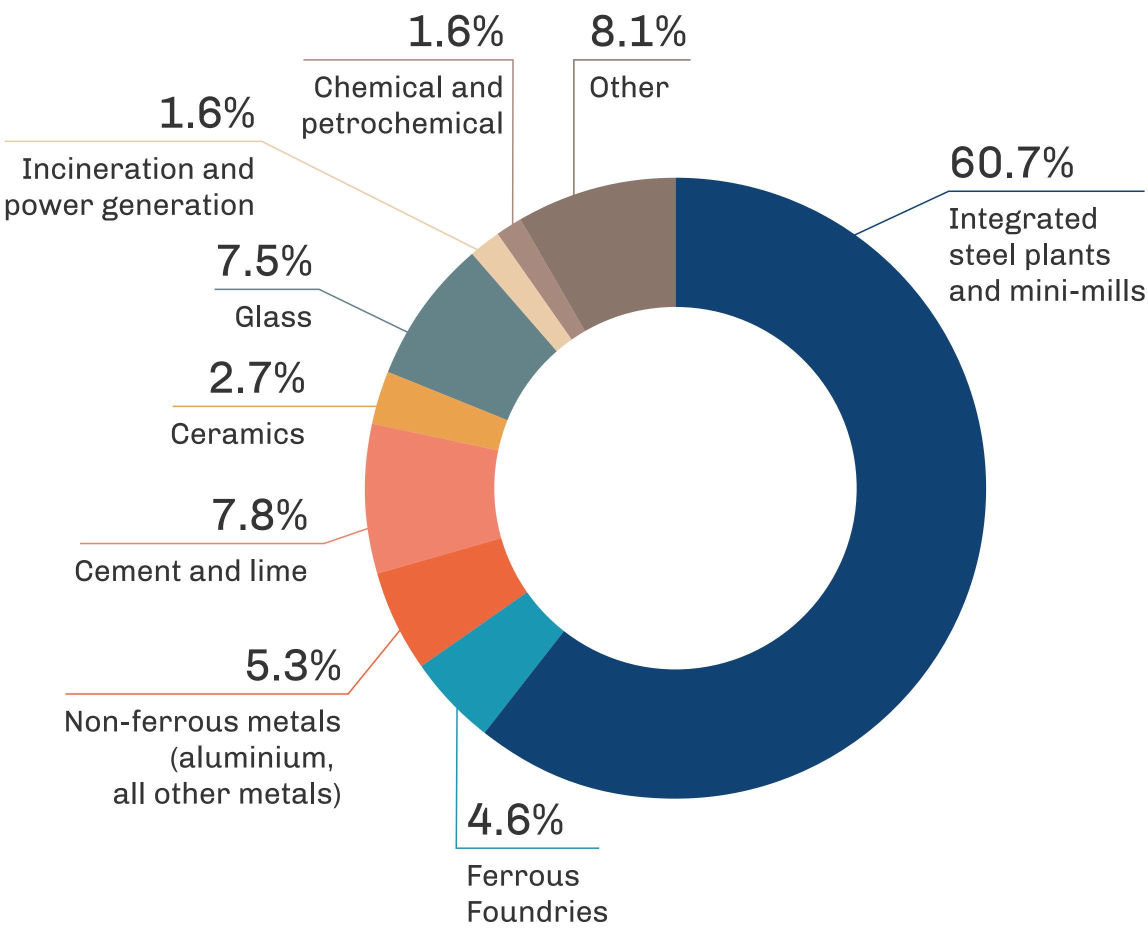
Source: Eurostat

NUMBER & PERCENTAGE OF PERSONS EMPLOYED PER CERAMIC SECTOR



Source: Eurostat, 2018

END-USE OF REFRACTORIES (AS % OF TOTAL PRODUCTION)



Source: PRE - European Refractories Producers Federation annual statistics, 2020

What are Ceramics

Ceramics encompass such a vast array of materials, manufacturing methods and applications that a precise definition is hard to pin down.

From a chemical point of view, ceramics are defined in terms of what they are not. They are non-metallic and inorganic solids – in other words, what we are left with when we take away metals and organic materials.

For many people, ceramics mean things like tableware, roof tiles, flowerpots, coffee cups, bricks in a fireplace, or a pizza oven or tiles on a kitchen wall. These products are known in the industry as traditional ceramics.

But beyond these everyday household items, there exist various other cases where ceramics are used.

Refractories as a part of ceramics are used as a refractory material because of their resistance to heat, mechanical stress or chemicals. Since they keep their shape and strength at high temperatures, they are used in all extreme-temperature industrial processes, primarily in metallurgical processes but also cement, glass, energy, chemical processes and more. Refractory ceramics are constantly innovating in close cooperation with these high-temperature processes to support their transformation, and a strong and autonomous European industry cannot be conceived without refractories.

Technical ceramics are considered to be one of the most efficient materials of our time. They are applied in many industries and include established products, such as insulators, engine parts, catalyst carriers, bone replacement, filters, and many others.

Technical ceramics are an active contributor to the well-being and construction of a resilient, carbon-neutral European society, and to achieving the goals and objectives of the EU Green Deal.

Most technical ceramics are exclusively inert and non-toxic, which means they are largely non-polluting. Recyclability is another key factor of sustainability, and technical ceramics can be effectively reused and recycled.

Technical ceramics are replacing heavy-duty metallic alloys in several challenging applications and industries, establishing ceramics as a cornerstone in the production of advanced engineering materials, which makes possible the shift towards high- and long-term performance material solutions with a deep impact on society and sustainability initiatives.

Technical ceramic components can tolerate higher temperatures and loading forces with a significant increase in the number of successful run cycles when compared to traditional materials. This means a considerable enhancement of efficiency, which is often a key factor in the indication of sustainability.

Advanced ceramics continuously play a significant role in clean energy production, from specialised piezoelectric systems for solar exchangers to solid oxide fuel cells and high-temperature roller bearings in high-efficiency wind turbines.

Innovative transformations in additive manufacturing of technical materials facilitate the manufacture of more complex, long-lasting systems for hyper-efficiency energy conversion systems.

How are ceramics made?

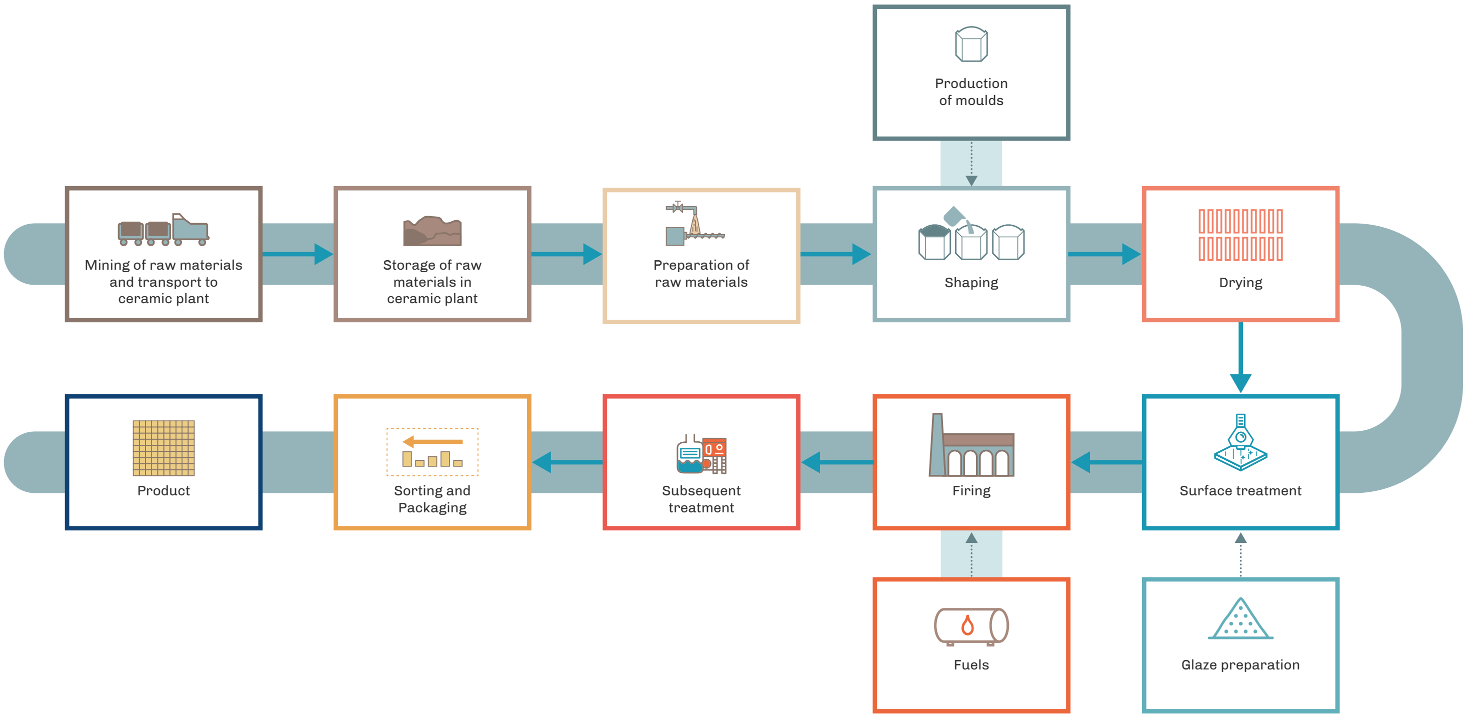
Raw Materials

Ceramics are made mainly from mined materials (such as clay, bauxite, magnesite), water, fire and air. The main raw material is clay, a resource available in large quantities. Technical ceramics and refractories and are made from a huge variety of raw materials such as aluminium oxide (more commonly known as alumina), magnesia, graphite, corundum and silicon carbide.

Manufacturing process

Ceramics are generally made by taking raw materials, adding additives, powders, and water, then shaping them into forms, which are dried and fired in a high-temperature oven known as a kiln.

MANUFACTURING PROCESS*



* Simplified diagram of the stages in the manufacture of ceramic products. The production process may vary according to the correspondent Ceramic sub-sector.

This process creates commercial products that are diverse in size, shape, detail, complexity, material composition, structure and cost.

Ceramic products that use naturally occurring rocks and minerals as a starting material must undergo special processing in order to control purity, particle size and particle size distribution.

These attributes are integral to the final properties of the finished ceramic.

Chemically prepared powders are also used as starting materials for some ceramic products. These synthetic materials can be controlled to produce granules or powders with precise chemical compositions and particle size.

The next step is to form the ceramic particles into a desired shape. This is accomplished by the addition of water/steam and/or additives such as binders, followed by a shape-forming process.

Some of the most common forming methods for ceramics include pressing, slip casting, extrusion, tape casting and injection moulding. More recently, we have observed a growing use of ceramic 3-D printing in technical ceramic applications with benefits not only in terms of functionalities but also in terms of resource efficiency.

The products are dried and heated to produce a rigid, finished product. Some ceramic products such as electrical insulators, dinnerware and tiles may then undergo a glazing process. Ceramics for advanced applications may undergo a machining and/ or polishing step to meet specific engineering design criteria.

Where are ceramics used ?


Other
Integrated steel plants and mini-mills
Chemical and petro-chemical
Ferrous foundries
REFRACTORIES
Incineration and power generation
Non-ferrous foundries (aluminium, all other metals)
Glass
Cement & Lime
Ceramics


Aviation, Aerospace & Defence
Cutting equipment
Superconductors
Electronics and batteries
HIGH-TECH AND INDUSTRIAL CERAMICS
Sporting equipment
Mobility
Medical
Renewable energy

Essential Ceramics

Today, our industry continues to manufacture cost-effective items that last a lifetime, delivering value to consumers and industries alike.

Ceramics – a unique sector, unique products with exceptional performance in many areas.

Heat & fire resistance

Ceramics can withstand very high temperatures but are poor conductors of heat, factors that give them qualities of resistance and stability. Not only do ceramics contribute to fire safety in buildings but they are also used in many industries where high heat is essential for production, from steel to glass. Conventional ceramics are well known for their resistance to heat, being fired in kilns at temperatures well beyond 1000°C, but coarse ceramics used in industrial applications are even more heat-resistant.

Insulating/thermal properties

Fired clay is naturally insulating. This quality, combined with a judicious design of the cells (honeycomb), means that clay wall bricks are perfectly suited to the new energy performance requirements of the building sector. In addition, the high inertia of these bricks, by offering a regulation of the interior temperature whatever the season, plays a determining role in thermal comfort.

Durability and strength

Ceramic products can last thousands of years – you only have to look at a Roman aqueduct or a Grecian urn to appreciate the amazing strength and longevity of ceramics. Today, our industry continues to manufacture cost-effective items that last a lifetime, delivering value to consumers and industries alike. Ceramics can also be recycled easily, reducing waste streams and contributing to the circular economy.

Safety

Ceramics are safe products, and the industry's many operators throughout the supply chain adhere rigorously to the highest health and safety standards. As a result, the ceramic industry in Europe has an enviable health and safety record compared to similar industries, and the customers who buy European ceramic products can be assured that they are tested to the highest safety standards. For example, ceramic tableware and porcelain comply with European legislation on food contact materials, guaranteeing consumers health and safety.

Hygiene

Ceramic products are inert and do not emit substances in the indoor environment, preserving indoor air quality. They also contribute to hygiene thanks to their ease of cleaning. After each use, a simple washing in a dishwasher sanitises all ceramic and porcelain products for the table and catering industry. Moreover, certain ceramic tiles have antibacterial properties.

Affordability

Not every ceramic product is as expensive as a Ming vase! In fact, the European ceramic industry prides itself on creating accessible, affordable products that offer a lifetime of value, whether for the consumer market and affordable housing or for hi-tech applications.

Creativity

Europe's ceramics companies are at the forefront of new technological developments in the sector – in manufacturing, design and marketing. It is this creative capacity that continues to facilitate Cerame-Unie members' entry into new markets beyond the EU. And with this creativity comes a rigorous commitment to quality, recognised worldwide.

Versatility

Cerame-Unie members' versatility is clear from our commitment to innovation. We make ceramic products from the simplest teacup to the most sophisticated capacitator. The industry is as versatile as clay itself. Creative and versatile ceramic products strengthen the resilience of this industry.

Ceramic hip replacement

A key component of essential and strategic value chains

Ceramics are central to many other industries and sectors. They are used in various industrial processes, including energy production, chemical production and metallurgy. Ceramics play an essential role as the base of everyday household items, but technical ceramics can be found in applications from electronics, healthcare, security and transport, renewable technologies, aerospace and defence.

Ceramics & COVID-19

Like many industries, the ceramic sector has been hit hard by the Covid-19 pandemic and its effects. Cerame-Unie's members, have, as far as possible, continued to maintain production and secure as many jobs as possible throughout the value chain. Our products have played a key role in limiting the spread of viruses and bacteria by providing inert surfaces, such as wall and floor tiles, that are easy to disinfect. Ceramics are also extensively used in a wide range of medical technology, such as respirators.

Preheated steel ladle with refractory ceramics

Continuing our Path towards Climate Neutrality

Committed to the European Union's climate ambition for 2030 and 2050

Ambitious goals

The European Union has set ambitious climate goals and shown global leadership in tackling climate change. With its overarching European Green Deal and legally binding European Climate Law, the EU has set the continent on a clear path to decarbonisation.

The European Climate Law legislates the goal set out in the European Green Deal for Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55 per cent by 2030, compared to 1990 levels. The European Climate Law entered into force on 29 July 2021.

Climate neutrality by 2050 means achieving net-zero greenhouse gas emissions for EU countries, mainly by cutting emissions, investing in green technologies and protecting the natural environment.

The ambition of the European ceramic industry

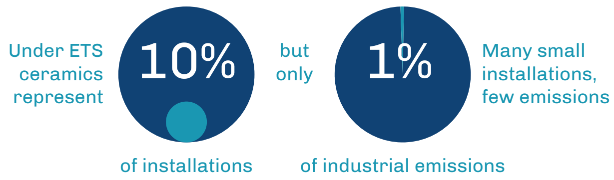
The European ceramic industry is both an energy-intensive industry and a manufacturer of products that will enable energy and carbon savings in other sectors. Our industry has been deeply rooted in the European economy for millennia and is committed to all three pillars of sustainable development, including environmental sustainability. We have therefore mapped a way forward to achieve Europe's ambitious climate goals. However, our industry does not operate in isolation. We are part of an interconnected industrial value chain that includes many stakeholders and actors, both upstream and downstream. For the European ceramic industry to meet its goals, a confluence of conditions ranging from the decarbonisation of electricity to the availability of hydrogen and the development of new technologies will be needed.

Objectives of the European Climate Law

- Set the long-term approach for meeting the 2050 climate neutrality objective through all policies, in a socially fair and cost-efficient manner
- Establish a more ambitious EU 2030 target, to set Europe on a responsible path to becoming climate-neutral by 2050
- Create a system for monitoring progress and take further action if needed
- Provide predictability for investors and other economic actors
- Ensure that the transition to climate neutrality is irreversible

Our current emissions

Producing ceramics is an energy-intensive process. Total emissions from the European ceramic industry amount to 19 million tonnes of CO_2 annually, which is roughly 1% of Europe's total industrial emissions covered by the EU Emissions Trading System (ETS). On the other hand, being mostly composed of SMEs and small emitters, ceramic installations represent 10% of all industrial installations under the ETS.

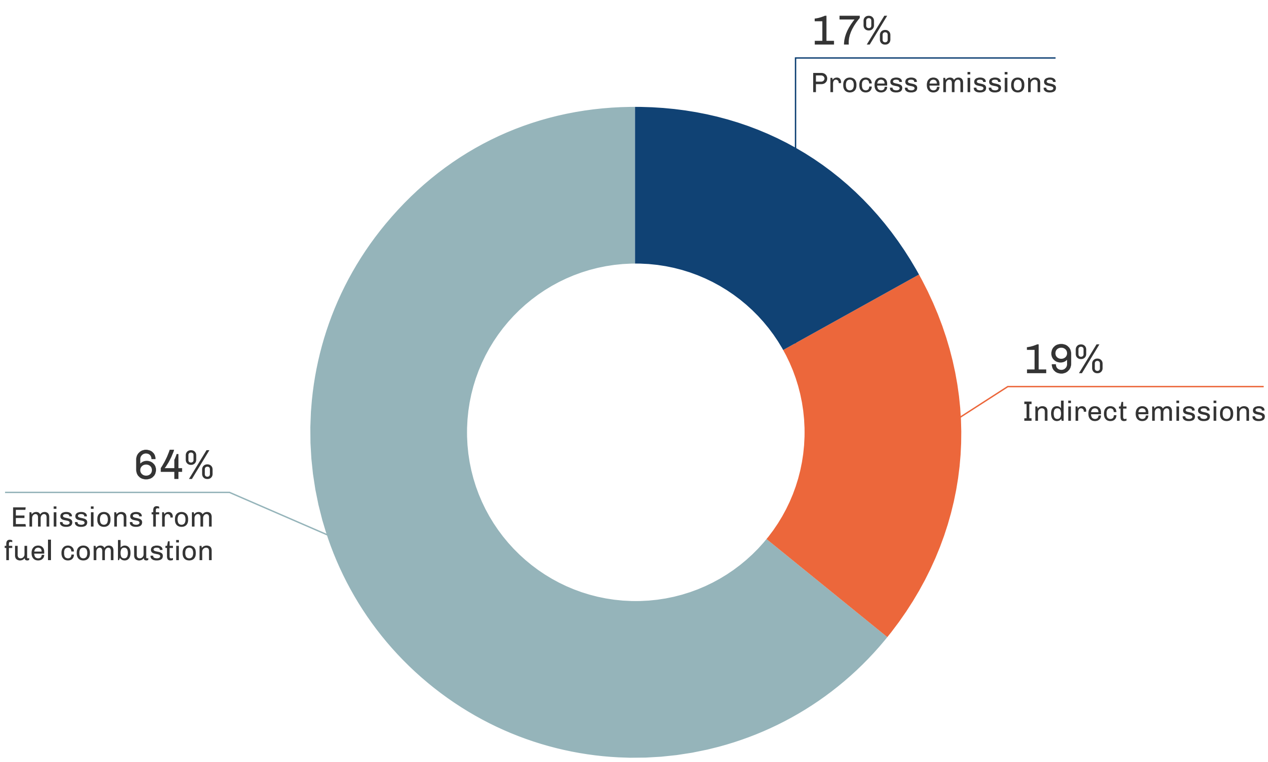


Source: Cerame-Unie

Emissions linked to ceramics production can be broken down into three main categories:

- Fuel combustion for drying and heating process.
- Process emissions generated by mineralogical transformation of the clay.
- Indirect emissions, mainly from electricity production.

SHARE OF EMISSION SOURCES IN THE CERAMIC INDUSTRY IN 2020



Source: Cerame-Unie

Around 90% of emissions comes from three sectors: bricks and roof tiles, wall and floor tiles and refractories. The proportion between the different emission types varies significantly, depending on different processes, plants, products and raw materials (particularly for process emissions which represent 30% of total emissions in the bricks and roof tiles sector and can be as high as 60% of total emissions in the clay blocks sub-segment).

The way forward: Our emissions reduction model

Methodology

The European ceramic industry performed the most extensive data collection on CO_2 and energy ever, updated and further developed its inventory of technologies from the first Ceramic Roadmap made in 2012, collected all assessments and expertise available at national level and drew conclusions in terms of what climate neutrality would mean for the ceramic industry: how it could be achieved, based on which technologies, which decarbonised fuels, how much of these fuels would be required, under which conditions and at what cost.

Past achievements

The European ceramic sector has reduced its total emissions by **around 33**% since 1990, and by more than 45% since its emissions and production peak in the years 2000s, mainly by optimising processes, making production more efficient and fuel substitution.

However, the most significant reduction in carbon emissions occurred in the 1980s when European ceramics almost entirely switched from solid fuel (mainly coal) to natural gas, the most carbon-efficient fossil fuel.

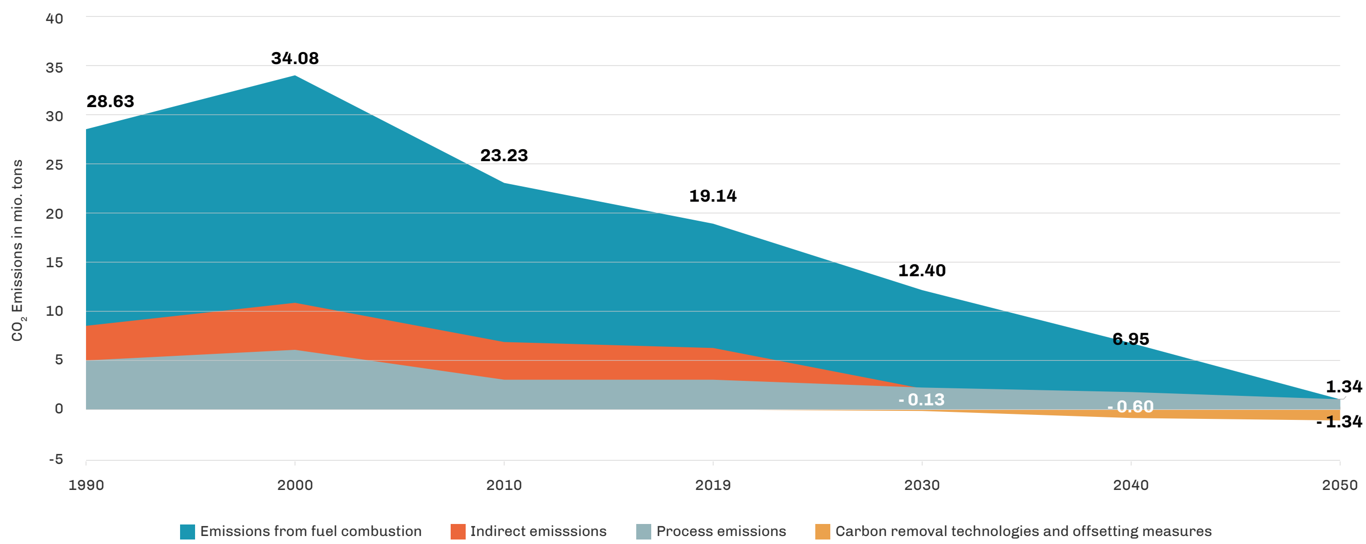
Emissions reduction model

Our emissions reduction model combines a range of measures to achieve a gradual reduction of emissions to reach carbon neutrality by 2050. These include:

- A switch to renewable energy (green hydrogen, biofuels and decarbonised electricity).
- A reduction in process emissions.
- Innovation and increased efficiency in the manufacturing process.
- CO_2 capture CCS/CCU.
- Other carbon removal technologies and offsetting measures.

The following chapter describes the projected measures in greater detail.

CO_2 REDUCTION PATHWAY



Source: Cerame-Unie

The following table presents the main technologies deployable in the ceramic industry to contribute to climate-neutrality targets. It also shows how far advanced each technology is. Not all technologies may be applied to all sectors, and it is not yet clear how, and to what extent, they will be applied. Most of the technologies presented are future technologies or complete breakthroughs. For these technologies to develop and to be applied, several conditions are essential – in particular, the support of industry regulators. These conditions are further described in the policy recommendations section.

Technologies	Technological advancement status (1-low advancement, 5-fully available)
Microwave-assisted drying	■■
Heat pumps	■■■■
Biomass	■■■■■
Biogas	■■■■
Syngas	■■
Green hydrogen	■■
Electrification	■■
CCS - CCU	■

Assumptions & external conditions

The CO_2 reduction model assumes that:

- There is a constant level of production and a similar product mix between 2020 and 2050.
- The real emissions for the year 2019 were taken as a basis for the estimations, as 2019 was a more representative year in terms of production levels (due to the COVID-19 pandemic, the year 2020 was not a representative year, as the emissions were exceptionally low during this period).
- Zero-emissions technologies, especially for the firing processes, will be available in a relatively short term, so as to allow the progressive renewal of assets, whose operational lifetime often exceeds 20 to 30 years.
- All barriers regarding the availability of alternative fuels (such as green hydrogen or biogas) are overcome, and that these fuels are made available in sufficient amounts and with a competitive price throughout Europe.
- Obstacles for the technical application and availability of alternative fuels will progressively be removed from 2030 and would allow the industry to move to breakthrough solutions, such as hydrogen, biogas or electricity in equal proportions.
- A gradual decarbonisation of the power supply throughout Europe.
- Gradual availability and acceptance of CCUS.

Switching to renewable energy

More than four fifths of our industry's emissions come directly from energy use. A switch to renewable energy, whether renewable electricity, green hydrogen, green synthetic gas or biofuels, will drastically reduce emissions. Our roadmap is based on a gradual decarbonisation of the power supply and an increased availability of green hydrogen, green synthetic gas and biofuels.

Depending on the type of plant and local availability options, some plants could switch to decarbonised electricity whilst others could eventually use biofuels, green hydrogen, or green synthetic gas. Since kilns can be used for more than 40 years and a switch of fuel type represents a major capital investment (except for a switch to biogas for plants that currently use natural gas), the choice of energy type and the availability of a regular and affordable fuel supply are necessary and vital.

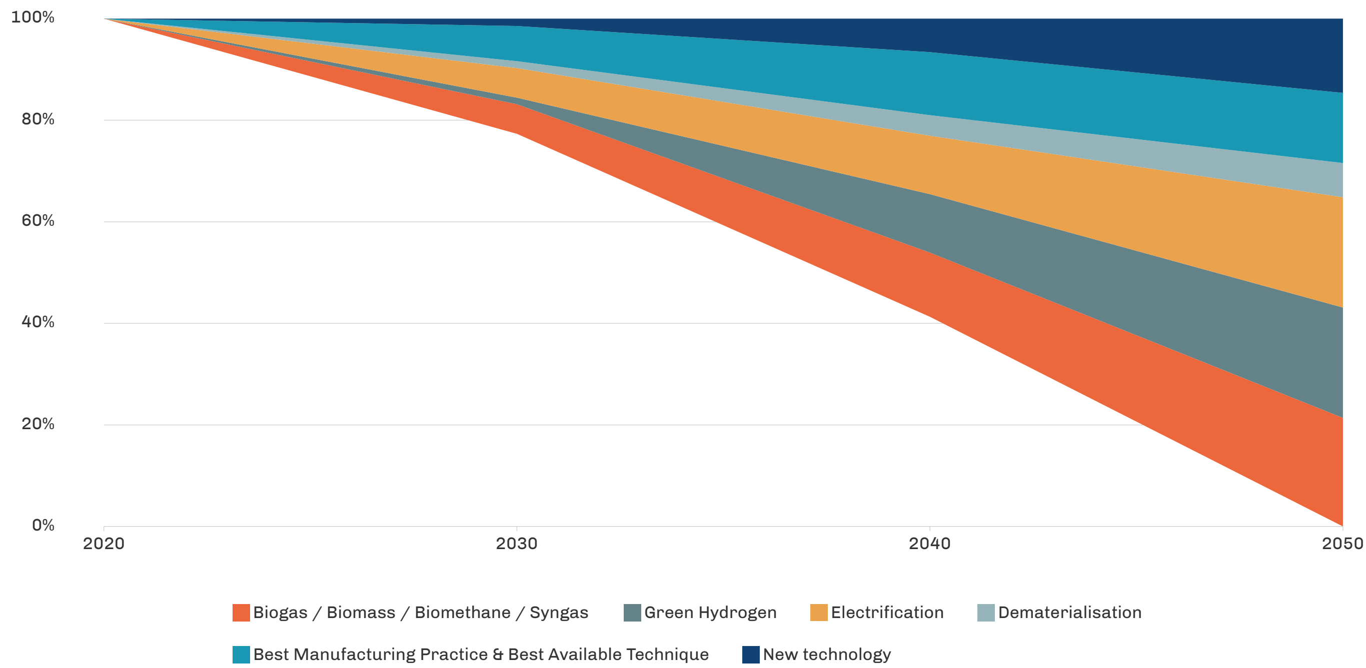
In parallel, the industry is committed to continued improvements in the energy efficiency of installations, to reduce overall energy demand. This includes the increased use of recycled material, the adoption of best available technologies and best available management practices, and the embrace of new technologies.

Available technologies and management practices include the installation of improved kilns, dryers, thermostats and seals as well as implementing automated controls. Heat savings can also be achieved by improving thermal insulation through the use of novel refractory linings, coatings and other ceramic materials.

Recovery of excess heat is also an important way to reduce fuel consumption. This can be done by capturing kiln gases to preheat the combustion or dryer. Smart design of manufacturing facilities is also a key factor because the physical distance between the different processes, such as firing and drying, can lead to energy savings.

Under this vision of a climate-neutral industry, in 2050 the European ceramic industry would have a projected energy need of around 140,000 terajoules. This would be one third less than in 2020, thanks to improvements in energy efficiency.

MEASURES CONTRIBUTING TO THE REDUCTION OF EMISSIONS FROM FOSSIL FUEL COMBUSTION



Source: Cerame-Unie

Biogas and green synthetic gas technologies are already available, with varying levels of penetration in different Member States, and the technology can be scaled up. We have therefore included them in a larger proportion in the energy mix anticipated for 2030. Available volumes are expected to rise until 2040 and 2050, but compared to hydrogen and electrification, biogas and green synthetic gas will play a smaller role.

Until 2030, we expect only small quantities of green hydrogen to be available for the ceramic industry due to demand from other sectors such as freight transport, pricing issues and a lack of infrastructure throughout Europe. We have assumed increased availability of green hydrogen from 2040.

The model also includes the electrification of one third of the ceramic manufacturing process.

Process emissions

Some emissions related to the production of ceramics are called process emissions. These are caused by the chemical decarbonation of carbonates in raw materials such as limestone or dolomite during sintering. In 2019, these emissions amounted to 3.34 Mt CO_2.

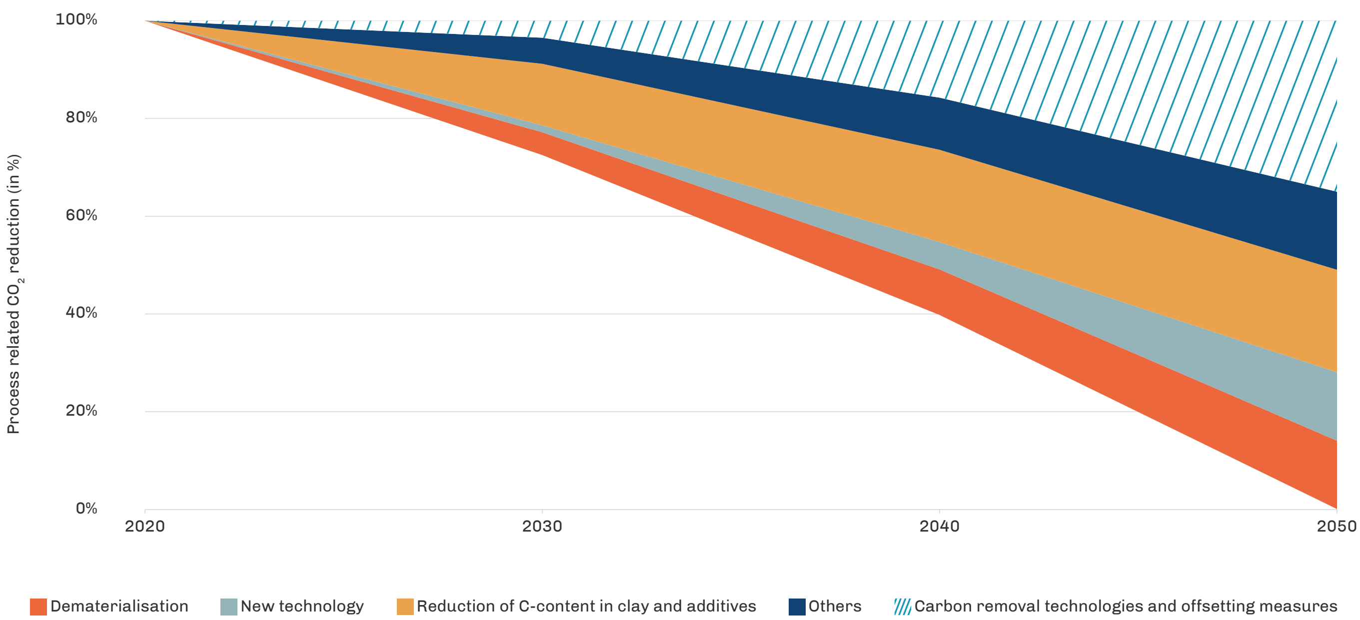
The amount of process emissions from clays differs, depending on the composition of the minerals and the local geology. The use of locally available raw materials avoids long-distance transportation, reduces CO_2 emissions and allows for local job creation. It would therefore not be environmentally sound to relocate factories and jobs to reduce process emissions.

Process emissions are inherent to the raw materials, are a natural by-product of the firing process and are much harder to abate without capture technologies. They cannot be avoided completely, at a competitive cost, and would probably need to be offset by biogenic methods.

We have identified measures that can be combined to reduce process emissions. These include:

- Reduction of carbon-containing additives.
- Minimisation/optimisation of the carbon content of clay mixes, while ensuring that this does not lead to higher transport related emissions.
- Dematerialisation (smaller quantities of raw materials for the same use).
- Introduction of new technologies.
- Carbon removal technologies and offsetting measures.

MEASURES CONTRIBUTING TO THE REDUCTION OF PROCESS RELATED EMISSIONS



Source: Cerame-Unie

As we approach 2050, some process emissions will have to be removed by using carbon removal technologies and offsetting measures. These measures could include the use of Carbon Capture and Storage (CCS) and Carbon Capture and Use (CCU).
Until cost-effective breakthrough CCS technology is developed on an appropriate scale for the ceramic sector, the installation of CCS is likely to remain prohibitively expensive for some time after its installation in some energy-intensive sectors. In addition, in some countries, CCS is 'forbidden by law'.

The geographical dispersal and varying scale of ceramic plants – compared to, for example, those in the steel and cement sectors – as well as the nature of the exhaust fumes from ceramics manufacturing, makes it unlikely that the whole ceramic industry will pioneer CCUS, although it may be interesting in the mid to-long term for some subsectors.

Annual alternative energy needs

The table below presents the annual alternative energy needs of the ceramic industry to achieve the carbon neutrality target by 2050. In fact, the industry will need nearly 50,000 terajoules each of green hydrogen, biogas and green electricity by 2050. These amounts are not available to industry currently, and their supply does not depend on industry itself but on many factors, such as infrastructure and the right legal and policy framework.

TABLE OF ALTERNATIVE ENERGY NEEDS DERIVED FROM EMISSIONS REDUCTIONS

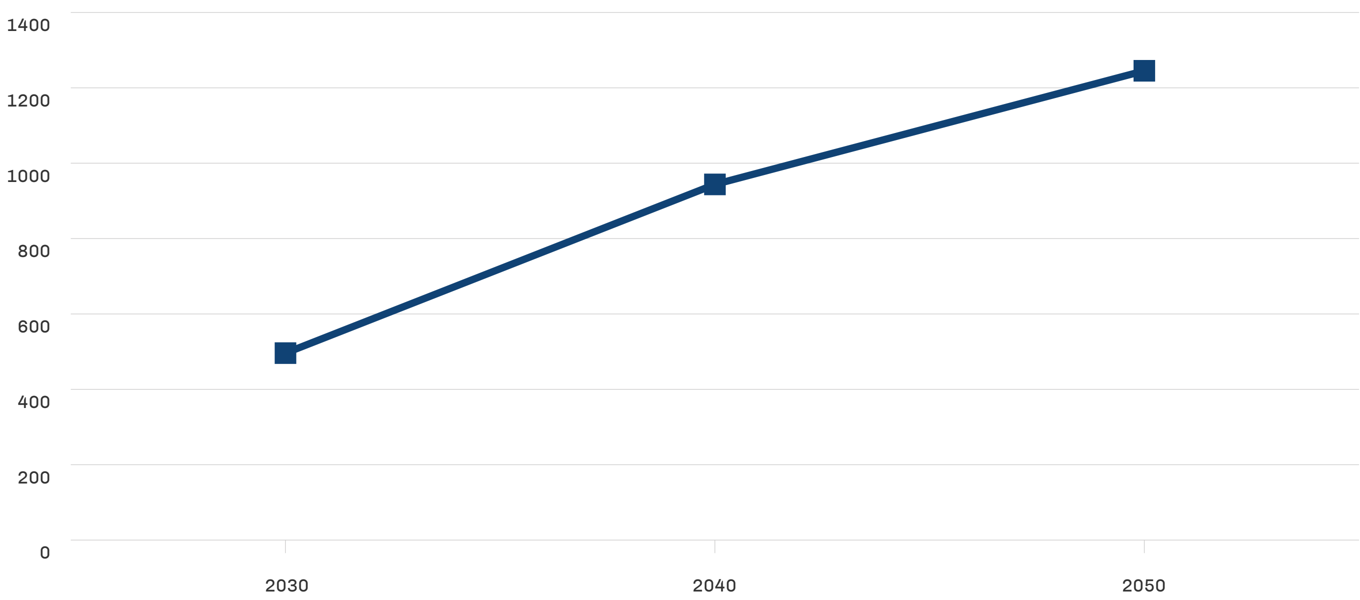
Year	Total energy need (TJ)	Biogas (TJ)	Green Hydrogen (TJ)	Green electricity (TJ)	Green electricity (Gwh)
2030	196,350.76	12,836.07	2,852.46	12,836.07	3,565.86
2040	166,911.25	27,811.48	25,315.58	25,315.58	7,032.67
2050	140,087.35	47,065.59	47,778.70	47,778.70	13,272.92

Source: Cerame-Unie

Development of annual abatement costs

The main question that the industry asks itself is the question of costs. How much will the transition to carbon neutrality cost? According to our model, we estimate that the annual costs to reach carbon neutrality will grow sharply in time. Taking into account the assumptions used for the purpose of this roadmap and detailed assessments made at national level, the ceramic industry considers that **by 2030, the annual decarbonisation costs will exceed €500 million**. The annual costs will progressively grow to nearly **1 bn EUR per year in 2040** and will exceed **1.2 bn per year in 2050**. Consequently, many preconditions need to be met to enable this type of investments in our industry. **The total cumulated abatement costs until 2050 are estimated at around 27 bn EUR.**

ANNUAL COSTS (IN EUR MIO.)



Source: Cerame-Unie

Ambitious climate neutrality targets cannot be achieved by the industry alone. Indeed, the achievement of such objectives depends to a great extent on external factors on which the industry has no influence: an appropriate regulatory framework ensuring a fair level playing field, access to finance, new technologies and decarbonised energy source.

Various conditions, some of which are outside the ceramic industry's reach and control, must be in place. Legislators and regulators must ensure an investment-friendly framework, and that the risks connected with carbon leakage, which is defined as industry relocating to countries with less stringent climate laws, are mitigated. The current system of free allowances up to a benchmark level is ensuring a minimum level of protection, provided that the carbon price does not disproportionately increase as a result of speculation of economic actors outside the EU ETS, and should be maintained as long as necessary.

For this purpose, benchmarks should be fair and not penalise heterogeneous sectors such as ceramics by ensuring that the benchmark reflects the real energy mix evolution in the sector (e.g. reconsider the role that a few biomass installations, sustainable or not, have on ETS benchmarks). In general, policy constancy in relation to unsustainable uses of biomass should be ensured throughout all EU climate and energy legislation.

It is also vital for the ceramic industry that carbon leakage measures maintain our competitiveness in export markets, considering that ceramic sectors export up to 40% of their production outside the EU.

Moreover, the regulators must enable the development of breakthrough technologies, not only by setting up the right legal framework but also with targeted financial and other incentives.

The development of relevant infrastructure must also be enabled across Europe – especially the support of technology shifts linked to changes of fuel source in ceramic plants. With more than 1,200 installations across all EU countries, the security of energy supply is a priority for the ceramic industry.

Ceramics, as an energy-intensive industry, needs a constant supply of quality fuel (whether green hydrogen, syngas, biomass or natural gas) to ensure uninterrupted production processes. Any unplanned interruption can lead to severe damage to kilns that work 24 hours a day, seven days a week.

Another aspect to unlock the necessary transformation is the question of the affordability of alternative energy sources. For example, electrification of kilns is currently considered in most ceramic sectors as economically unsound. This is due to the much higher cost of electricity compared to natural gas, and also due to the lack of incentives to move towards electric firing (for example as a result of the ceramic industry's ineligibility for indirect cost compensations related to electricity under the ETS State Aid Guidelines). Access to green electricity is key for the green transition of our industry, and we rely on the supply, which also depends on the needed infrastructure.

To summarise, we need support to reach our goal, but the necessary conditions are not in the hands of the industry itself. Many obstacles remain in legislative, financial and technological frameworks. We believe that these obstacles can be overcome step-by-step to create a framework that enables the industry to fully decarbonise and reach our net-zero target by 2050.

Policy recommendations

IN ORDER TO SUCCESSFULLY ENGAGE ON THIS PATH TOWARDS CLIMATE NEUTRALITY, THE CERAMIC INDUSTRY WILL NEED:

Continued and sufficient carbon leakage protection

- Fair performance benchmarks representative of the sector-specific energy mix evolution, not penalising heterogeneous sectors and SMEs.
- Full consistency in the treatment of unsustainable use of biomass across the whole climate and energy legislative arsenal. All unjustified effect of biomass installations on the ETS benchmarks must be avoided.
- Carbon leakage protection measures should allow EU producers to remain competitive in export markets.

A carbon price incentivising investments

The CO_2 price should not limit the industry's ability to invest in technological transition and should not be affected by carbon market speculation from investors not covered by the EU ETS.

A stable, reliable legal framework

Investments in new kilns and machinery in ceramic processes are made for a period well beyond 20 years. Such long term investments can only be made if the regulatory framework offers sufficient stability and predictability.

Sufficient financial support

Sufficient financial support both for research and innovation and for investments (CAPEX) and to mitigate higher running operational costs (OPEX). The industry should also have access to Carbon Contracts for Difference.

Secure infrastructure and a stable supply of green energy

The appropriate transportation, storage and distribution infrastructure in green energy (electricity, green H2, biogas or syngas) to ensure stable supply at a reasonable and competitive price.

Energy at a competitive price and better mechanisms to cope with energy crisis

Ensuring access to affordable energy prices, in particular in the context of energy crisis, by preventing and investigating possible anti-competitive behaviour in the energy market, promoting common energy purchase and energy stocks in the EU, and studying the functioning of the gas and electricity markets to improve the internal energy market in the mid- and long-term. Most importantly, instruments should be put into place so that appropriate financial and fiscal support or compensation can be activated on a short-term basis as soon as an energy crisis occurs.

Equal access to green energy

The EU should firmly establish and enforce a principle of sector neutrality for all decarbonised energy sources. Equal access to hydrogen and other green energy sources should be guaranteed for all end-users.

Full access to finance

Sustainable finance should be accessible to all sectors in the process of implementing their environmental and energy transition, including heterogeneous industries and SME sectors. Moreover, EU funding policy should be material-and technology-neutral.

Facilitate permitting process

Rapid, stable and straightforward permit processes for green investments (in the energy sector as well as in industry), and a consequent reduction in bureaucracy, particularly for SME sectors.

Building and renovating in an energy-efficient and resource-efficient way

The energy-saving potential, durability, and reusable qualities of ceramic construction materials (clay bricks, blocks, roof tiles, pavers, expanded clay, wall and floor tiles and sanitaryware) have been known for centuries. With a renewed focus on energy efficiency and circularity, the European ceramic industry will be central to reducing energy use and construction waste.

Supporting the Renovation Wave

Renovation of our existing building stock and focusing on near zero energy building are paramount to meeting Europe's decarbonisation objectives.

Ceramic construction materials are durable, affordable and provide comfortable, energy-efficient, safe and healthy homes to millions of people in Europe.

Ceramic construction materials provide high levels of safety in case of fire or flood. They also ensure a high indoor air quality, as no toxic emissions emanate from the building fabric into the internal environment.

Ceramic wall and roof systems not only increase comfort but reduce heating and cooling costs and emissions.

Collectively, buildings in the EU are responsible for 40% of our energy consumption and 36% of greenhouse gas emissions.

Innovative ceramic sanitary appliances contribute to water and energy efficiency, notably in the context of voluntary smart tools promoted by the industry such as the Unified Water Label.

Ceramic construction materials will be pivotal to Europe's new near-zero energy building stock as well as its Renovation Wave.

Clay brick cavity walls and monolithic clay block walls with integrated insulation can normally reach any required insulation value by varying the insulation thickness. They also offer a maintenance-free solution for a lifetime.

Ventilated facades create an air chamber between the cladding material and the structural surface of the building. Such systems can easily be applied in renovation on any material. A building with a ventilated façade system can be in some cases 35% more energy efficient. Other benefits of ventilated facades include the reduction of dampness on walls, deterring the formation of thermal bridges and providing a comfortable indoor climate by preventing heat from escaping in winter and entering in summer, and improved sound absorption.

Doing more with less

Houses with pitched roofs are more space-efficient than those with flat roofs, offering more floor space for the same footprint.

Furthermore, clay brick walls can store solar and internal heat gains and radiate the energy out when it is needed. Moreover, bricks are a cost-effective solution to treat thermal bridges.

Ceramic roof tiles are among the most energy-efficient types of material. They have a high thermal emittance, are recyclable and last for decades. They also allow for natural ventilation, creating a thermal barrier that prevents heat loss through the roof.

Keeping it cool

Energy efficiency is not only about keeping heat in. In warmer, southern European climates, keeping heat out is equally important. With air conditioning becoming ever more popular, ceramic roof tiles can help to keep heat out and cool air in, thus reducing demand for air conditioning systems.

- **Thermal emittance**
  Instead of absorbing heat into our buildings, ceramic roof tiles and ventilated facades reflect heat back into the air.
- **Regulate humidity**
  Moreover, bricks and ventilated facades regulate moisture and provide a comfortable indoor climate and dry walls.
- **Solar reflectance**
  Lighter-coloured ceramics help reflect the sun's rays during the day, allowing buildings to stay cool naturally.

- **Individual tile installation**
  Since in some regions roof tiles are installed individually rather than in an overlapping sheet style, they allow for more natural ventilation, creating an airspace that forms a thermal barrier.

Bricks and roof tiles are affordable, locally produced materials that are central to both new energy-efficient buildings and renovating our existing building stock. Reducing emissions using sustainable ceramics will go hand in hand with providing local employment.

Deconstruction & circularity: going back to our roots

Abandoned buildings have been used as a source of materials for new construction for thousands of years. Bricks were cleaned and reused, and tiles recycled: until the early 20th century, demolition crews took care to keep construction materials intact. But labour costs, regulation, building standards and perception have largely ended this sustainable practice.

Durability

For many people in Europe, buying a home is a once-in-a-lifetime decision and an investment for the future. The durability and the quality of the materials is thus essential. In addition, the lengthening of the average duration of mortgage loans (more often 30 years than 20 years) requires choosing a sustainable building that will limit the need for maintenance and preserve the value of the property.

Ceramic construction products are affordable, resource-efficient and have high durability, requiring little or no maintenance. A brick house has an average life span of more than 150 years, as do clay pipes and buildings containing expanded clay. Sanitaryware appliances and ceramic tiles for flooring and walls can have a life span of up to 50 years, which compares favourably to alternative materials.

Reuse

Increased urbanisation and the depletion of natural resources are making the demolition / reconstruction model increasingly unsustainable. Ceramic construction materials have been reused for centuries, and now contribute to innovative thinking about how we can give new life to construction materials.

Existing buildings can be reused *in situ*, or dismantled and rebuilt in a different location. For example, industrial buildings can be converted into offices or housing. Because of their durability, brick buildings are perfectly suited to these types of conversions, which not only reduces the need for natural resources, but preserves the heritage of our built environment.

Reusing existing buildings avoids their demolition and preserves resources otherwise needed to construct a new building. In addition, the reuse of existing buildings can preserve their cultural and historical value. In urban areas, this type of adaptive reuse is an effective way to reduce urban sprawl and the associated environmental impact.

In many cases, ceramic construction materials can be reused:

- Walls using facing bricks in dry stack systems or bricks stacked with lime mortar can be easily dismantled and the bricks reused. Brick manufacturers have also developed hanging systems where bricks or brick slips glued on panels are detachably connected to an underlying frame, to be easily reused.
- Roof tiles are easy to disassemble, have a very long service life and can be reused after deconstruction.
- In addition to the traditional recycling applications, new floor tiles are developed that do not require glue or cement and are thus removable and reusable.
- Ceramic pavers are frequently reused, which increases their economic value. Clay pavers have a reuse percentage of at least 90% and an average lifespan of 125 years.

Recycling

When ceramic construction materials cannot be reused, they can be recycled for a range of purposes. Secondary raw materials (being waste in other industries) are also used in the manufacturing of ceramics.

Closed loop recycling

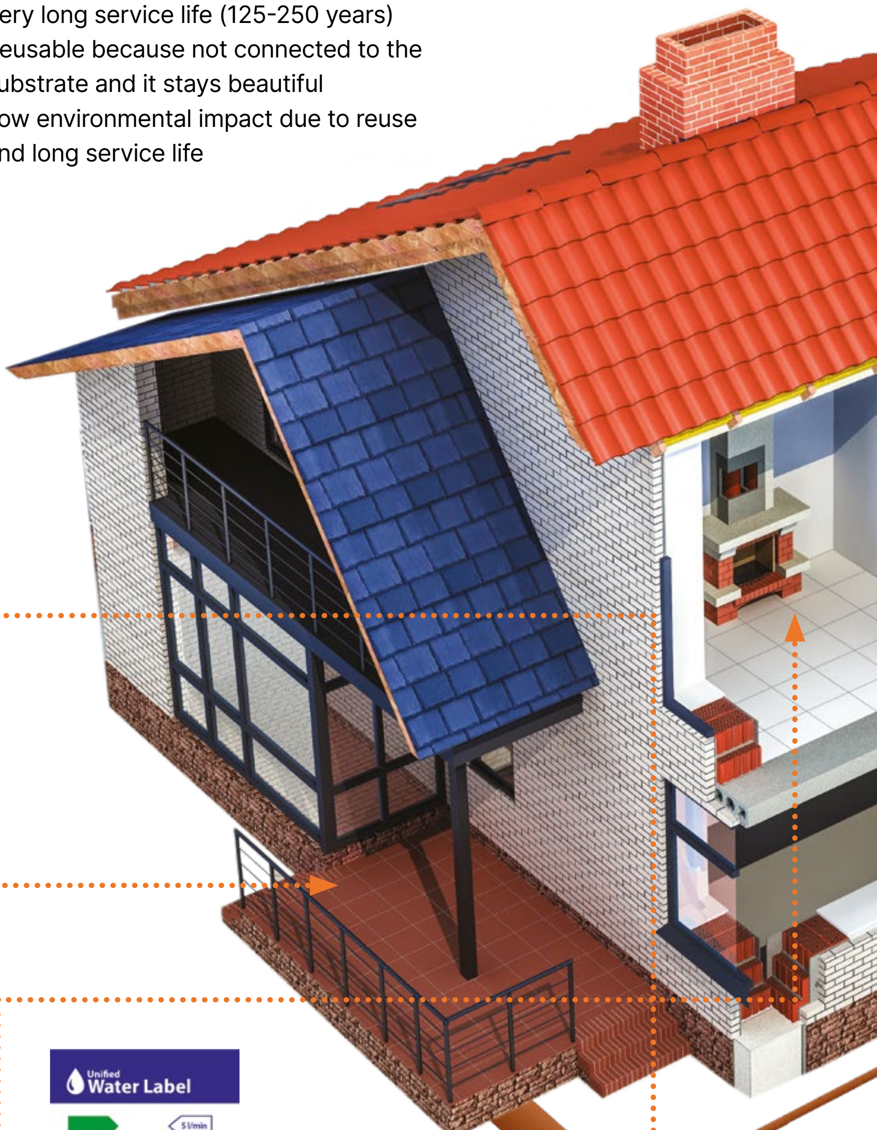
- The use of internal production residues from the production of bricks and wall and floor tiles as a substitute for raw materials is common practice across Europe.
- Ceramic clay powder that can be used as substitute to Portland cement, and crushed brickwork, can be used also in the production of cement clinker.
- Other organic sources, such as sawdust, rice husks or sunflower seed shells are used in the clay block production process to improve insulation properties.

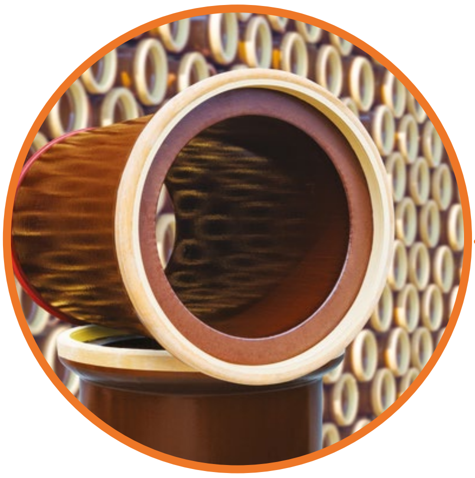
Open loop recycling

- Many ceramic construction products can be crushed to a defined grain size distribution and used as a lightweight aggregate in the production of concrete blocks.
- Several ceramic construction products that have reached the end of their useful life are commonly recycled: for example, in backfilling pits and quarries, as a water-bound cover layer, as aggregates for substructure, as a surface layer in road construction, as vegetation substrate or as roofing substrates for green roofs.
- Sanitaryware can be recycled.
- Recycled wall and floor tiles can be used to stabilise the ground when constructing new roads.

Clay pavers

- Made from clay, a renewable raw material
- Very long service life (125-250 years)
- Reusable because not connected to the substrate and it stays beautiful
- Low environmental impact due to reuse and long service life





Ceramic sewage (clay pipes)

- Made from clay, a widely available raw material and up to 30% recycled material
- Very long service life (100+ years)
- High-quality recyclable, C2C certification
- Limited environmental impact

Ceramic wall and floor tiles

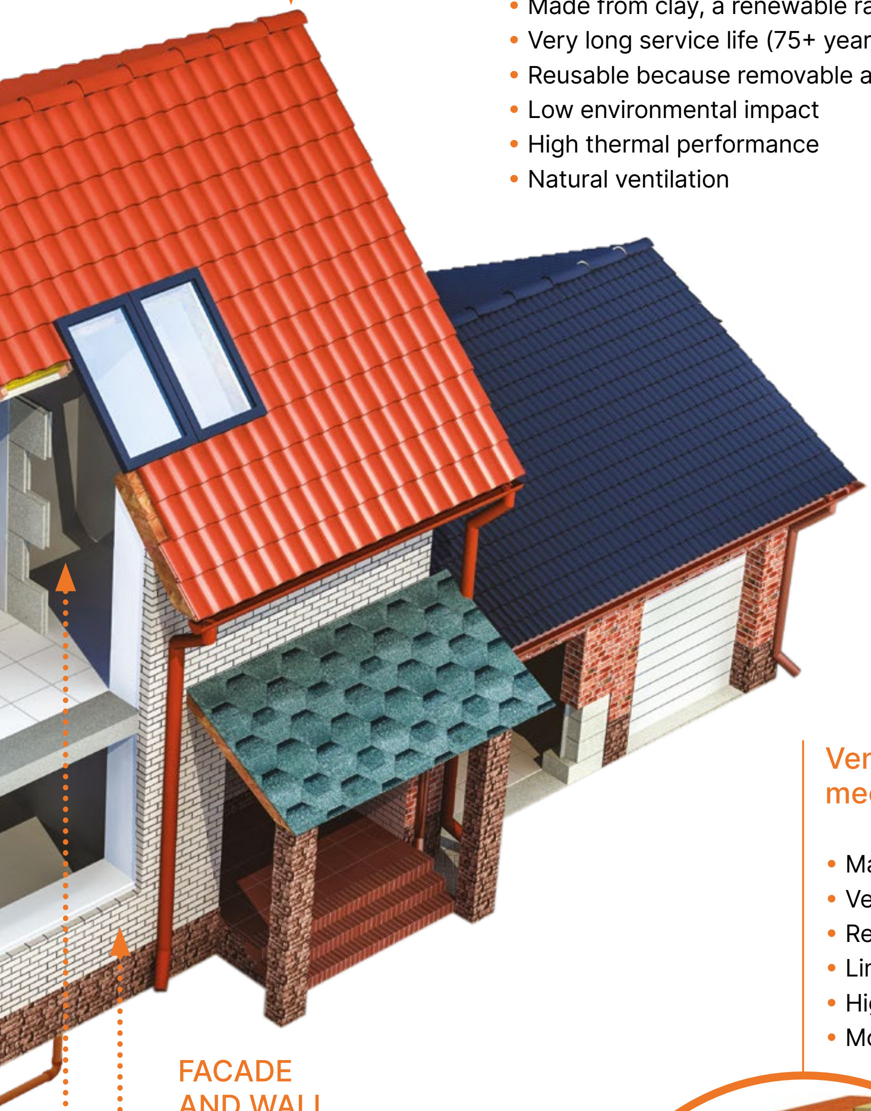
- Made from clay, a widely available raw material
- Long service life (+50 years)
- High-quality recyclable, C2C certification
- Low environmental impact
- No toxic emissions

Sanitaryware

- Made from clay, a widely available raw material
- Very long service life (+75 years)
- Reusable due to long service life
- Low environmental impact
- Contribute to water efficiency

Ceramic roof tiles

- Made from clay, a renewable raw material
- Very long service life (75+ years, glazed 100+ years)
- Reusable because removable and a long service life
- Low environmental impact
- High thermal performance
- Natural ventilation



Ventilated facade with mechanical anchored tiles

- Made from clay, a widely available raw material
- Very long service life (+75 years)
- Reusable because removable
- Limited environmental impact
- High thermal performance
- Moisture prevention

FACADE AND WALL SOLUTIONS

Clay blocks for walls

- Made from clay, a renewable raw material
- Very long service life (+150 years)
- High quality recyclable when using small joints and clay plaster finish
- Limited environmental impact
- Thermal and acoustic performance
- No toxic emissions
- Moisture prevention

Brick masonry

- Made from clay, a renewable raw material
- Very long service life (+150 years)
- Reusable when using lime mortar, otherwise recyclable
- Limited environmental impact, low impact when using lime mortar
- High thermal performance

Policy recommendations

A holistic and integrated approach to building renovation

Cerame-Unie supports the objectives of the Renovation Wave. A holistic and integrated approach is recommended to building renovation to stimulate the whole construction sector. Building renovation is not just about energy efficiency; the efficiency of the water load used should not be neglected. In this context, Cerame-Unie supports smart tools such as the Unified Water Label, which offers clear and easy-to-understand information on water and energy use of bathroom products.

Promoting both renovation and new construction

Both renovation and new construction should be promoted. Mandatory examinations should be carried out to determine whether deep renovation (purely energetic renovation) or demolition and subsequent rebuilding is ecologically and economically more reasonable. It is sometimes more efficient to entirely rebuild a building than to renovate an old one. In addition, a new building can be more energy-efficient, and will be better adapted to new social needs as well as to recent urban developments around it. Therefore, renovation and new construction should receive the same fiscal and financial incentives.

Supporting holistic life cycle assessment schemes

Ceramic construction products manufacturers support holistic life cycle assessment schemes for buildings and for many years have provided the necessary environmental and sustainability product data via the use of voluntary environmental product declarations (EPDs). In this context, Cerame-Unie supports the work of CEN/TC 350 and welcomes European initiatives such as Level(s).

Supporting the New European Bauhaus initiative

The European ceramic industry welcomes and supports the New European Bauhaus initiative, which aims at shaping future ways of living according to key principles of sustainability, inclusion and quality of experience, thus contributing to the well-being of citizens.

Implementing the Construction Products Regulation

The Construction Products Regulation (CPR) provides a common technical language to assess the performance of construction products. Cerame-Unie believes that the revision of the CPR should bring as few legal changes as possible, to avoid confusion in the market and additional costs to manufacturers. In the short term, solutions should be found to the most urgent problems related to the implementation of the CPR, such as the backlog in the citation of harmonised product standards in the Official Journal of the European Union, to avoid legal uncertainty and instability for the industry.

Mobilising industry for a clean and circular economy

The European ceramic industry supports Europe's goal to move away from a linear 'produce, use, waste' model to a circular model in which resources and materials are reused, recycled, or recovered.


Newly built building with facade made of reused bricks, Denmark

Resource efficiency is not only about using less, but about making better use of existing resources. Clay, our industry's main raw material , is available in abundance. Furthermore, ceramic products are resource-efficient and stand out with their high durability thanks to their long lifespan. And after the end-of-life stage, ceramic products can be reused or recycled.

The ceramic industry is already making a major contribution to the shift towards a circular economy through innovative production processes and sustainable products – for example, by minimising raw material consumption and waste generation during the production process, optimising raw material selection, refining product design and promoting supply-chain cooperation for recycling.

Durability

Resource efficiency is not only about 'using less', but about 'using better'. Ceramic products, and in particular ceramic construction products, are resource-efficient and have a high durability, requiring little or no maintenance. Studies show that a brick house can have an average life span of more than 150 years, as do clay pipes and buildings containing expanded clay. Research also shows that clay pavers can have a lifetime of 125 years. Sanitaryware appliances and ceramic tiles for flooring and walls can have a life span of up to 50 years, which is very high in comparison to alternative materials. Ceramic tableware and ornamentalware can last for decades.

Moreover, given the inert nature of fired clay, many ceramic products can be reused or recycled after the end-of-life stage, meeting the concept of cradle-to-cradle. In this context, the ceramic industry has developed solutions to minimise raw material consumption and waste generation during the production process, and has increased the reuse and recycling of products.

Innovation

Research and innovation in the ceramic industry has transformed the manufacturing process and the efficiency of raw materials. The industry has accomplished this through innovative technologies and product developments, the substitution of primary raw materials with recycled materials, the direct internal reuse or recycling of materials and the substitution of conventional fuels. In recent years, research has also focused on product design, in which digitalisation plays a key role. In the wall and floor tiles industry, some manufacturers have switched from rotary printing to digital printing: ceramic inks can be used instead of decorative pastes, so that only 20% of the raw material previously needed is used. Research on the application of digital printing in the glazing process suggests it offers great potential.

The circular economy in action

Bricks and Blocks

The use of internal production residues from brickmaking as a substitute for raw materials is common practice across the industry. Broken clay blocks can also be crushed to different sizes and used as a lightweight aggregate for making concrete blocks.

Dry stack systems for facing bricks have also been developed. These are easily dismantled, and the bricks can be reused. Bricks can also be reused when using lime mortar for the brickwork. And brick manufacturers have developed hanging systems in which bricks or brick slips glued on panels are detachably connected to an underlying frame and can easily be reused.

Roof tiles

Roof tiles are easy to disassemble and have a very long service life. They can be reused or recycled for other purposes: backfilling in pits and quarries, water-bound cover layers, aggregates for substructure or surface layer in road construction, coverings for tennis courts and sports fields, vegetation substrate and roofing substrates for green roofs.

Clay pavers

Ceramic pavers are almost always reused, and they even increase in economic value. Clay pavers have a reuse percentage of at least 90% and an average lifespan of 125 years.

Refractories

In the refractory industry, manufacturers can produce monolithic refractories and refractory bricks that contain between 20-80% of recycled material.

Virgin refractory materials can be substituted by recycled material originating from various industries.

Wall and floor tiles

Ceramic wall and floor tiles are increasingly being repurposed, and work is ongoing aimed at achieving zero waste in the manufacture of ceramic tiles by using ceramic waste in the body and glaze. Several manufacturers are also looking at producing tiles that can be reused.

Clay pipes

The minimum share of external recycled content now averages above 20%. In the vitrified clay pipes industry, it is possible to produce 100% recyclable clay pipes, consisting of about 40% secondary raw materials on average, and with a service life of more than 100 years.

Expanded clay

In the expanded clay industry, up to 90% of the product can be reused. Up to 100% of expansion clay additives and 10-15% of virgin clay can be replaced by alternative materials derived from other industry sectors.

Policy recommendations

Promote durable products

Use of long-lasting, reusable and/or recyclable products such as ceramic products should be encouraged, and a whole lifecycle analysis should become binding.

Overcome regulatory obstacles

Regulatory obstacles hampering further development of circular practices in the industry should be lifted.

Facilitate shipment of waste

Shipment of waste between different Member States is a complex process and leads to administrative overburden. Waste destined to valorisation must benefit from the principle of free movement of goods within the EU.

End-of-waste criteria for refractory ceramics

End-of-waste and by-products criteria are not harmonised at European level. This ambiguity in current legislation involving waste and byproducts creates a 'grey zone' which can lead to different interpretation between the manufacturers and local authorities. The industry needs to work with local governments to facilitate the use of spent refractories and minimise administrative obstacles. Specific criteria should be established for refractories to lift these obstacles.

Incentivise circular practices

Developing circular practices and adapting technical requirements of installations can generate significant costs for the industry. Incentives should be developed to encourage these practices.

Refractory lining in a tertiary air duct of a cement kiln

Contributing to EU's zero-pollution ambition

Europe's zero-pollution vision for 2050 is for air, water and soil pollution to be reduced to levels no longer considered harmful to health and natural ecosystems, and to respect the planet's boundaries by creating a toxin-free environment.

The European ceramic industry is committed to adopting the best available technologies to reduce all forms of pollution from its raw material extraction and throughout its production processes. We have a long history of working with regulators and local communities to reduce pollution. Ceramic products such as refractories, and the use of ceramics in catalytic converters, help to reduce harmful emissions.

Modern manufacturing

The European ceramic industry has been in business for thousands of years, continuously improving, and now has some of the world's most advanced manufacturing facilities. Both large- and small-scale plants feature state-of-the-art emission control technology, and continuous innovation has helped perfect manufacturing techniques that reduce emissions.

Reducing pollution

Air

Producing ceramics requires high temperatures, and the combustion of fuels to generate this heat produces air emissions. As the raw materials are heated, chemical reactions take place that generate air emissions, but advanced emission control technology has helped mitigate this. These techniques include the reduction of pollutant precursor input, process optimisation, sorption plants (adsorbers, absorbers), afterburners and filters. The adoption of green electricity or green gas for heat generation will substantially reduce CO_2 emissions.

Water

The amount of water needed to produce ceramics is limited, and most plants produce little or no wastewater. However, specific types of ceramics manufacturing require water, and the resulting wastewater can contain mineral components, inorganic and organic materials and some metals. Wastewater is increasingly being treated and reused to minimise the use of fresh water. Most ceramic plants now have closed water cycles, and rainwater is being used in some factories.

Soil

Modern ceramics manufacturing has a limited impact on our soil. The European ceramic industry has robust processes in place to avoid any form of soil contamination. Ceramics are inert materials and thus do not cause any harm to the soil.

Ceramics: essential for reducing pollution

Emission control systems

Ceramics have been a key component in catalytic converters for decades and have been instrumental in reducing transport-related air pollution.

Refractories

Refractory products are a vital element in all high-temperature processes, such as the manufacturing of metals, petrochemicals or glass. Innovation in refractory products makes these production processes ever more efficient, leading to reduced emissions.

Indoor air quality

Ventilated ceramic facades help enhance indoor air quality by keeping pollutants out, contributing to thermal efficiency and mitigating noise pollution.

An inert material

Ceramics are inert and do not leak pollutants, nor do they react with other substances in a way that could produce harmful pollutants. Ceramic materials used indoor are free of emissions of volatile organic compounds (VOCs) and ensure indoor air quality. As an inert material, ceramics in products such as water pipes avoid contamination, even if used over a very long time period.

Policy recommendations

Realistic requirements and fair implementation of the Industrial Emissions Directive

The revision of the Ceramic Best Available Techniques Reference Document (BREF) under the Industrial Emissions Directive (IED, Directive 2010/75/EU), and the revision of the IED should promote environmental objectives while ensuring realistic requirements that take into account the economic and technical feasibility for the various ceramic sectors. The implementation of the IED should also preserve a level playing field, not adding a disproportionate burden only on European companies. The European Union should make use of its trade policy instruments to promote equivalent environmental standards with its trading partners, for instance in Trade and Sustainable Development (TSD) chapters in Free Trade Agreements or through the implementation of its trade defence instruments by better taking into account non-incurred environmental costs in third countries.

Chemical strategy for sustainability

While ensuring the highest protection for the consumer, chemical legislation should ensure a level playing field with imports from outside the European Union, and not create unnecessary burden for European companies. This applies particularly to the treatment of intermediate substances, which are no longer present in the final product to which consumers are exposed.

A consistent legal framework

The various legislations designed to achieve the zero pollution objectives should be consistent and avoid unnecessary overlap. Such overlap in legislation would create confusion and lead to an excessive and unnecessary regulatory burden.

Access to funding

The use of ceramics in clean air technologies provides a strong example of the importance of our industry as an enabler for environmental objectives. We strongly believe that research and innovation support via access to European project funding should be ensured to continue on this path.

Preserving and restoring ecosystems and biodiversity

The production of ceramics in Europe relies on raw materials, principally clay, that are extracted in quarries in Europe and beyond.

Quarrying operations always have an impact on the environment. The European ceramic industry is committed to ensuring that the impact is limited, and that sites are rehabilitated. Careful planning, good stewardship and active rehabilitation minimise the negative environmental impact of our quarries and help biodiversity to thrive. Each quarry is carefully planned, and impact assessment studies are performed to map potential effects on local flora and fauna, noise pollution and dust levels.

Clay quarries do have an impact on the local environment but they do not require any chemicals, nor do they use explosives. Furthermore, the unique landscape, especially aquatic environments, created by quarrying operations can have a positive impact on habitats and wildlife in and around these quarries.

The European ceramic industry supports the European Union's Green Infrastructure objectives and focuses on promoting biodiversity so that ecosystems can deliver their many benefits to people and nature.

Principally, this means creating wildlife habitats on quarry sites, aimed at the conservation of endangered or threatened species and restoring species populations. Quarrying, as an extractive industry, creates holes and spaces that can then be filled with water to provide environments in which aquatic flora and fauna can flourish.

Through this approach, operational and rehabilitated clay quarries have become havens for wildlife, demonstrating that restoration of quarries can strengthen ecosystems, benefiting local biodiversity. Databases are being set up to document the biodiversity in used and restored pits; this is notably the case in Germany. Several European quarries have also been transformed into sites for the production of solar energy.

Transparency

Many sites host open days, inviting the local community to visit quarries and learn more about how careful management can benefit local wildlife and biodiversity. All biodiversity is also diligently logged in a series of databases that allow for a data-driven approach to measure impact and progress.

Partnerships

Rehabilitation projects are often implemented in partnership with conservation and wildlife organisations, or with academic institutions.

Bridging the gap between science and projects

Bridging the gap between theory and practice is pivotal to promoting biodiversity. A variety of different projects, and a broader assessment of their impact, will help establish best practices and reliable data.

Biodiversity in action

Examples of projects aimed at promoting or restoring biodiversity at clay quarries

Leeuwensche Waard

Country: The Netherlands

This joint project between Delgromij and WWF focused on the management of waterways to secure new habitats for local wildlife and to create a 290-hectare nature reserve.

Schlagmann Climate Protection Strategy 2020

Country: Germany

The project has reforested and rehabilitated a range of sites, providing new nesting grounds for birds and bee colonies.

Alsace

Country: France

The ceramic industry joined forces with a local association to develop 15 protected aquatic sites for amphibians.

Noala

Country: Italy

Since 1985, the operators have created a network of ponds to promote biodiversity, integrated into the Natura 2000 network and boasting more than 190 bird species. When the operating licence was renewed in 2009, the protected section was increased from 13 to 36 hectares.

Accelerating the shift to sustainable and smart mobility

Ceramics have been used in all forms of transportation for over a century because they are lightweight, can withstand high temperatures, are capable of insulating thermally and electrically, demonstrate excellent wear and corrosion resistance properties, and are safe as well as reliable.

Why are ceramics used in transport applications?

- High strength
- Electromagnetic compatibility
- Thermal insulation
- Corrosion resistance
- High heat resistance
- Low friction
- Chemical resistance
- Wear resistance
- Low weight
- Resistance to temperature shock

The shift to decarbonised transport will see an increased role for ceramic materials.

In vehicles with internal combustion engines, ceramics help reduce fuel consumption and pollution. Ceramics are, for example, a key component in catalytic converters and electronic engine management systems. Since the majority of Europe's vehicle fleet, especially heavy goods vehicles, will still rely on internal combustion engines for some time to come, reducing emissions from these engines is paramount. Ceramics in catalytic converters will also be key to reduce pollution for engines using renewable or e-fuels.

As we move towards increased electrification and the use of hydrogen as a transport fuel, ceramics will be become a key element of decarbonising transport because of their use in electrical systems, for example in thyristor housings.

A vital building block of smart mobility is the increased availability and use of public transport. Ceramics are used in a range of components on buses and trains, such as electrical systems and brakes.

The unique durability of ceramic materials used in the transport sector also ensures the longevity of the components, reducing the wear and the need for replacement parts.

Ceramic hydrogen fuel cells

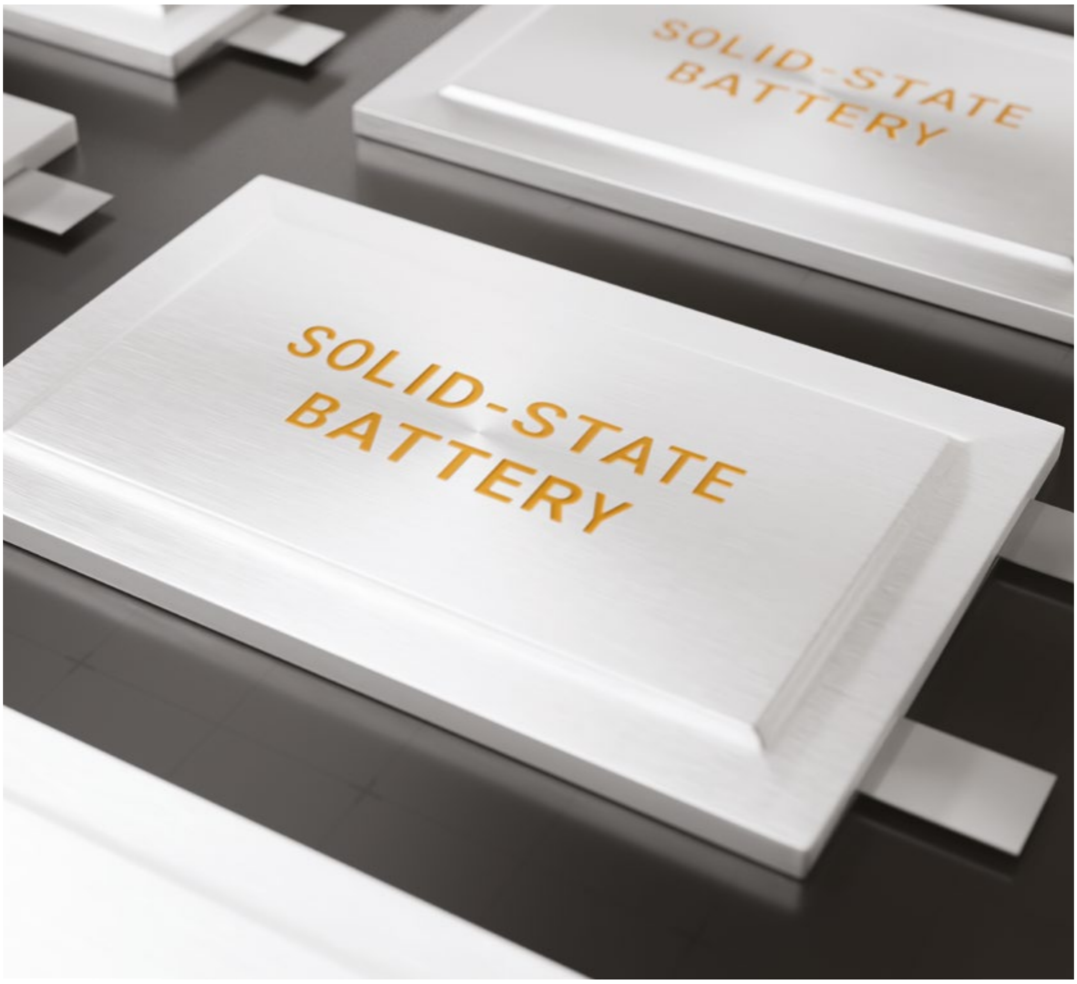
Ceramic fuel cells are highly efficient devices that convert chemical energy into electrical energy and produce no emissions if powered by hydrogen, providing a clean alternative to fossil fuels. Another advantage of ceramic fuel cells is that they can also use hydrocarbon fuels such as methane, meaning they can act as a bridging technology, which is an important asset in the move away from hydrocarbons towards cleaner energy sources.

Battery technology

Several battery technologies rely on ceramics to deliver performance, endurance and safety.

For example, solid-state batteries are safer because they rely on a solid electrolyte instead of the flammable liquids used in today's lithium-ion batteries, and could last longer too.

Ceramics are also an important component in NiCl-batteries, combining a long lifetime with safety and recyclability.



Policy recommendations

Strategic importance

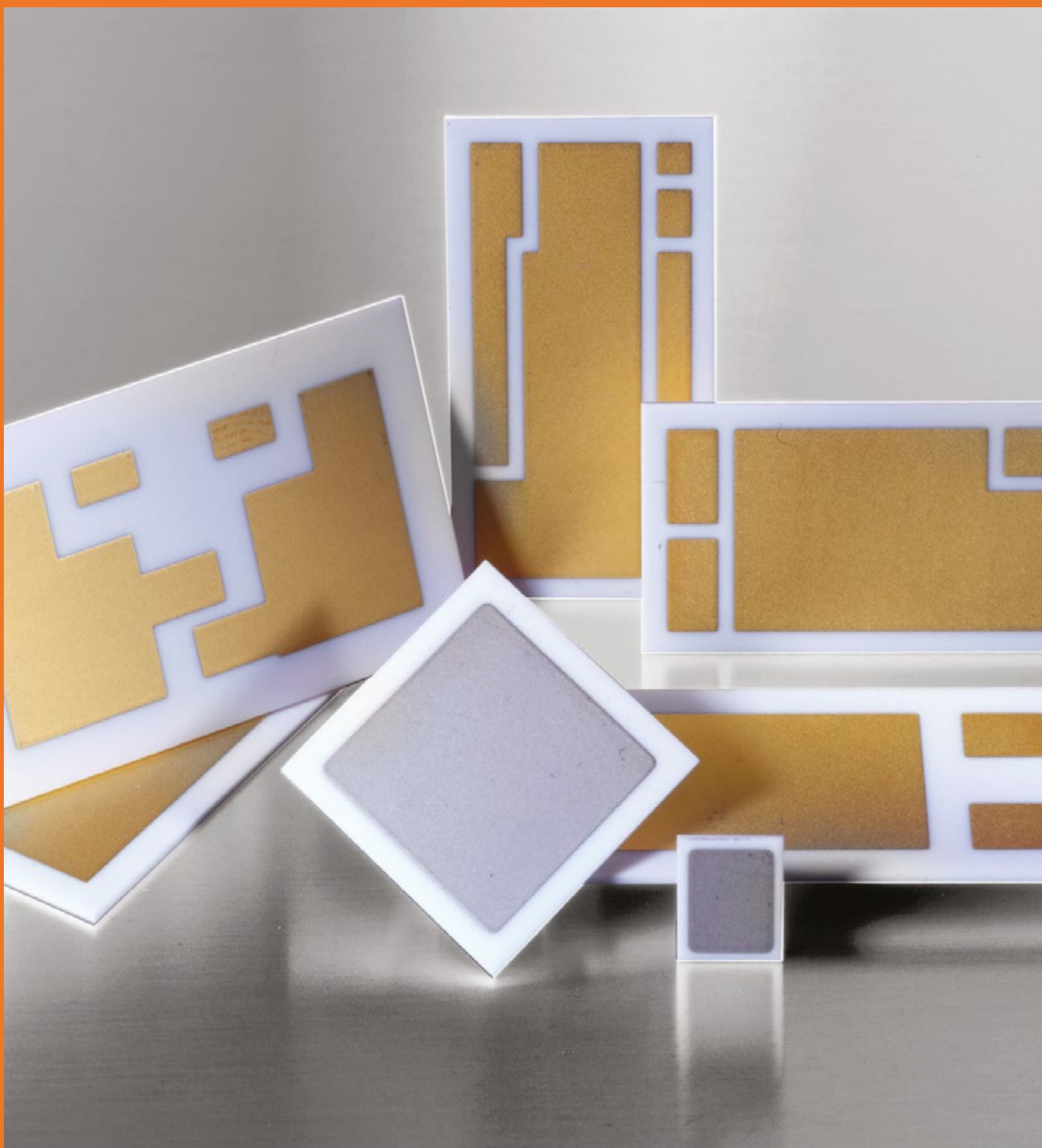
Acknowledge the strategic importance of technical ceramics.

Investments

Promote investments in Europe in this sector. Ensure technical ceramics are fully eligible to sustainable finance as enabling activities.

Research & innovation

Ensure full financial support to research and innovation in this sector.



A Just Transition

The European Union has set an ambitious goal for the reduction of greenhouse gas emissions, but also recognises that the transition to a decarbonised economy must be a just one.

Cost-effective energy efficiency and durability

The European ceramic industry will help lead a just transition by:

- Offering an ambitious pathway to decarbonising production.
- Supplying construction materials that make buildings inherently more energy-efficient.
- Providing solutions to reduce energy use and energy loss in other industries.
- Creating local skilled jobs in both manufacturing and downstream industries mainly in rural areas.
- Promoting circularity and protecting biodiversity.

A real pathway

As this document shows, the European ceramic industry has mapped out an ambitious roadmap to decarbonising production. However, this pathway presents several challenges that can only be overcome through close cooperation between policymakers and a broad range of other stakeholders, and with sufficient financial support for capital expenditure and innovation. Most importantly, this pathway will only be feasible if a level playing field is maintained, and if the required decarbonised, affordable energy infrastructure is made available to the industry.

Supporting the Renovation Wave

A key part of the European Green Deal is reducing emissions related to space heating and cooling in buildings, and increasing the energy efficiency of buildings through the Renovation Wave strategy. Bricks and clay blocks, and wall, floor tiles and roof tiles have either on their own or in combination with appropriate systems unique thermal properties that contribute to reducing the energy needs of Europe's building stock. Ceramic construction materials are a cost-effective, proven and local part of the renovation puzzle. Because of their flexibility and availability, ceramic construction materials also help European citizens adopt a more accessible and step-by-step approach to renovation.

Impact on emissions reduction in other industries

Innovative refractory ceramics offer resource-efficient solutions to downstream industries such as steel and other metallurgical processes, glass, cement and ceramics, and have played an essential role in the development of key breakthrough technologies.

Because ceramics help industries that are key to the Renovation Wave, for example insulation material and glass, by reducing their production costs, they can have a trickledown effect on cost, making energy-efficient renovation more affordable.

Skills for a just transition

A just transition and shift to a climate-neutral, resilient economy can only be achieved by providing citizens with the necessary skill sets and qualifications for future job profiles.

Identifying skills shortages and ensuring adequate supply of the right skills is essential to help deliver the goals and ambitions of the recovery pathway, EU Industrial & SME Strategies, and the green and digital transitions.

The European ceramic industry is committed to supporting the upskilling and reskilling of its workforce by providing and ensuring continuous, specialised and lifelong training, as well as building close and fruitful collaborations with academia, educational providers and communities.

Creating local jobs

The European ceramic industry is deeply rooted in local economies, and as an industry we aim to continue being a driver for local economies, innovation and employment. Around Europe, several ceramic clusters bring together a range of ceramic companies, from large plants to SMEs, in a single centre of excellence.

A multi-dimensional just transition

A multi-dimensional focus on a just transition will have several positive outcomes:

- Safeguarding local employment will ensure the 200,000 people working directly in our industry are part of the just transition.
- Locally-produced ceramics will ensure European citizens and business have access to quality products that are key to reducing their carbon footprint during the use phase.

Trade: the need for a level playing field

The European ceramic industry can compete on quality, price and design at a global scale, provided that the terms of trade are free, fair and sustainable.

We look to the EU to insist on clear, transparent and enforceable global rules that support the global outlook of our industry and, where necessary, to take corrective measures against discriminatory trade barriers.

The European ceramic sector should be able to export globally, unhindered by trade barriers. At the same time, the European market should be protected from unfair practices originating in third countries, such as illegal and environmental dumping, tariff circumvention, subsidies and intellectual property infringements.

Cerame-Unie is increasingly concerned by persistent barriers to trade, both tariffs and non-tariff barriers, that consistently impede the industry's access to old and new markets.

While EU anti-dumping and anti-circumvention measures have gone some way towards ensuring fairness, Cerame-Unie remains alarmed by the increasingly unfair trading patterns that threaten the health of our industry in Europe. Dumping, overcapacity and market distortions – individually and collectively – continue to pose a threat to the EU ceramic industry, putting at risk skilled jobs and the future of EU businesses.

Additionally, external trade plays a paramount role in facilitating the transition to a greener economy. To ensure a level playing field and preserve the competitiveness of the EU industry, "green reciprocity" should be integral to the enforcement of preferential agreements with trading partners to ensure that environmental costs are not unilaterally borne by the EU industry.

Maintaining a level playing field should be a key priority of EU trade and investment policy. It is vital to building a resilient and competitive EU industry internally and externally.

Policy recommendations

PROMOTE FAIR, SUSTAINABLE, AND FREE TRADE

Promote market access

Strengthen the EU toolbox against barriers to trade in third countries to ensure fair access to export markets for EU ceramic producers, especially SMEs. This would also entail a more consistent and predictable use of existing EU instruments such as the new Trade Enforcement Regulation (EU 2021/67) and the Trade Barrier Regulation (EU 2015/1843).

Step up the efforts against global trade distortions and ensure a global level playing field

Particular attention should be given to the increasing environmental costs that the EU industry incurs vis-à-vis non-EU producers, thereby undermining the competitiveness of the EU industry. This aspect should be taken into account in the context of the EU Generalised Scheme of Preferences as well as in the calculation of the dumping margin in Anti-Dumping proceedings.

Competitive exports

Measures such as the Carbon Border Adjustment Mechanisms (CBAM) should complete, not replace, existing carbon leakage measures and should be conceived to maintain the EU industry's competitiveness, not only on domestic but also on export markets, by including the export adjustment mechanism in the ETS Directive.

An effective use of EU Trade Defence Instruments

Effective TDIs should tackle unfair trade practices as soon as a serious threat of injury to the EU industry arises.

Address strategic dependencies on raw materials

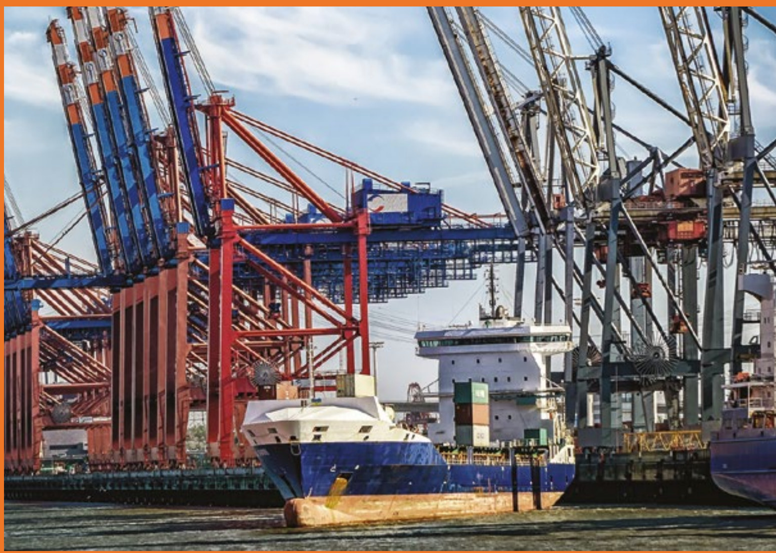
Ensure fair access to raw materials and reduce the EU's dependency on third countries for industrial supply chains.

Seek by all means to achieve the open strategic autonomy of the EU

SKILLS & QUALIFICATIONS

Mobilisation of all relevant stakeholders

(EU, national and regional institutions, industry, sector associations, academia, educational and training providers, research and technology entities, etc.) to take **concrete actions for the upskilling and reskilling of the EU workforce**, through available instruments such as the **European Skills Agenda** and the **Pact for Skills.**



Glossary

Abrasive - Materials or products used to polish and finish a workpiece through rubbing, i.e. abrasion

Best Available Technology (BAT) - Best available technology for achieving a high general level of environmental protection, developed on a scale that allows implementation in the relevant class of activity under economically-viable conditions

Biodiversity - The number and variety of organisms present in an ecological complex in which they naturally occur, e.g. in an ecosystem

Biogas - The end-product of the breakdown of organic feedstock by anaerobic digestion. Biogas is composed of methane, carbon dioxide, water and hydrogen sulphide and is used as a biofuel

Biomass - A renewable energy source, material from biological origin, mainly plants, that will be used directly or converted into other energy products

Carbon Capture and Storage (CCS) - A climate mitigation technology that allows carbon dioxide to be captured then transported and stored in depleted oil and gas reservoirs or saline aquifers

Carbon Capture and Utilisation (CCU) - The process of capturing carbon CO_2 for the purpose of recycling it in another process. CCU does not result in permanent geological storage. Instead it converts CO_2 into a more valuable product or substance.

Carbon and Job Leakage - The phenomenon when one country or region unilaterally implements climate legislation, resulting in the relocation of industries and jobs and in an increase in emissions in a less-regulated region, with no global reduction in CO_2 emissions

Ceramics - Inorganic materials, made of non-metallic components, not all including clay, and which become permanent after a firing process

Climate neutrality - Achieving net zero greenhouse gas emissions by reducing those emissions so they are equal or lower than the emissions that get naturally removed through the planet's absorption capacity.

EU-27 - The European Union (EU) is an economic and political partnership between 27 European member countries

EU Emission Trading System (ETS) - European policy to combat climate change by reducing industrial greenhouse gas emissions cost-effectively. The EU ETS has created a market to effectively put a price on carbon emissions and trade them

Firing - The heat treatment of ceramic products in a kiln to harden them and develop a vitreous or crystalline bond

Greenhouse Gas - Atmospheric gases that absorb and emit radiation within the thermal infrared range. The burning of fossil fuels has contributed to an increased concentration of these gases in the atmosphere. Includes methane which is 25 times more potent than carbon dioxide as a greenhouse gas

Kiln - High-temperature installation used for firing ceramics

Process Emissions - Carbon dioxide emissions produced during the manufacture of ceramic products whose raw materials contain carbonates

Restoration - Restoring degraded or damaged ecosystems by human intervention

Refractory - A material that retains its strength at high temperatures

Small and Medium Enterprise (SME) - A company with less than 250 employees and where either the turnover is less than €50m or the balance sheet total is less than €43m

Syngas (Synthesis gas) - A combustible gas mixture containing carbon monoxide, carbon dioxide and hydrogen, which is an end-product of the gasification process of a carbon-containing fuel, such as the gasification of coal, biomass, waste to energy gasification or steam reforming of natural gas

Vitreous - A 'glassy' application to ceramics that as a result of a high degree of vitrification has extremely low porosity

Vitrification - The progressive partial fusion of clay as a result of a firing process

Volatile Organic Compounds (VOC) - Organic chemicals with high vapour pressure at room temperature conditions, causing large numbers of molecules to evaporate or sublimate and enter the surrounding air. There is concern about some VOCs which are toxic

Cerame-Unie The European Ceramic Industry Association

www.cerameunie.eu

Cerame-Unie Aisbl (CU)
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Based in Brussels since 1962, it is the voice of the European ceramic industry to the EU institutions.

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