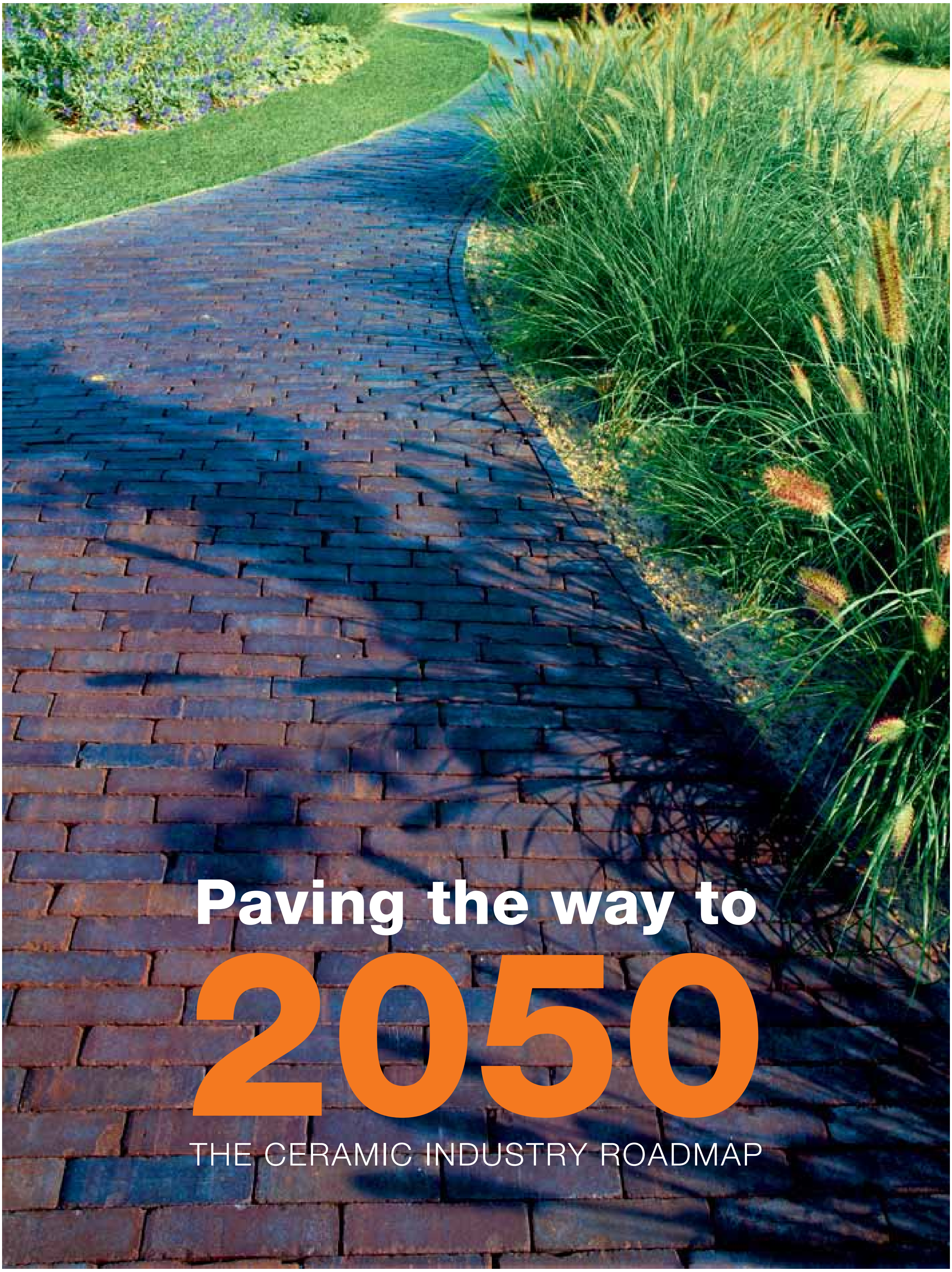
Cerame-Unie The European Ceramic Industry Association



Cerame-Unie is the trade association representing the European ceramic industry. Our members include national associations and companies, bringing together over 2,000 companies in 25 EU Member States. We engage in a constructive dialogue with the EU institutions, international partners and social and environmental stakeholders. Our aim is to share our expertise in construction, industry applications, standardisation, trade, raw materials, climate change, energy, environment and health and safety.

The European ceramic industry has a rich cultural legacy and takes a responsible approach to the environmental and social impact of its activities.

Our members cover eight ceramic sectors:
- Abrasives
- Bricks and roof tiles
- Refractories
- Sanitaryware
- Tableware and ornamentalware
- Technical ceramics
- Vitrified clay drainage pipes
- Wall and floor tiles

CONTACT US AT:

Cerame-Unie A.I.S.B.L.
The European Ceramic Industry Association
Rue de la Montagne 17
1000 Brussels
Belgium
sec@cerameunie.eu
www.cerameunie.eu

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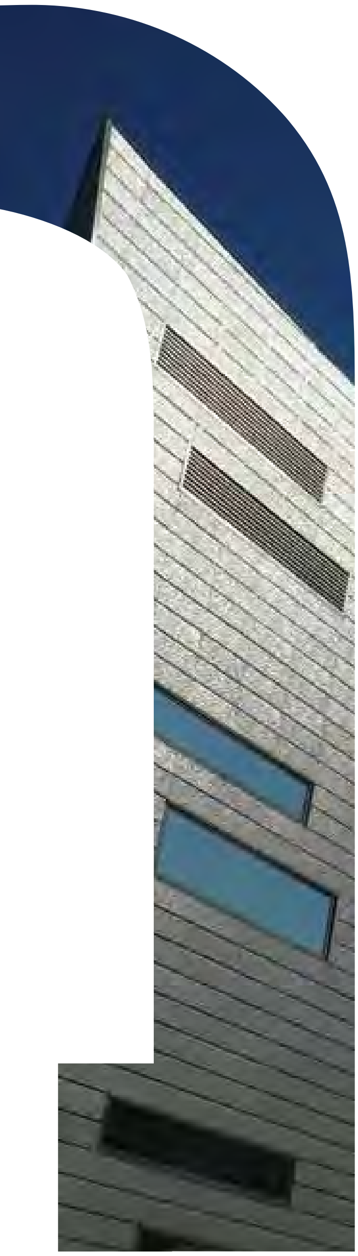
Cover image: Dries Van den Brande

Executive Summary



A strategic sector for the EU

The European ceramic industry today employs over 200,000 people in the EU-27, around 80% of them in SMEs. World-leading companies are headquartered in the EU and the industry develops highly-skilled and trained employees.

As one of mankind's oldest industries, the European ceramic industry is a strategic and future-oriented sector. Through its continued commitment to innovation, the ceramic industry has demonstrated its willingness and ability to contribute to the development of a competitive low-carbon and resource-efficient economy in the coming decades.

With its wide range of applications, from construction to consumer goods, industrial processes and cutting-edge technologies, the ceramic industry constantly develops innovative and high-value solutions that improve our quality of life and facilitate vital progress in downstream sectors. Indeed our products play an essential and very often indispensable role for energy and resource efficiency in other sectors. By enabling resource and energy efficiency in all these sectors, ceramics play an essential role in EU society.

The need for a lifecycle approach

Ceramic products are designed to be durable. This is achieved through high-temperature firing of a wide range of minerals, from locally-sourced clay to natural or synthetic high-quality industrial minerals, to produce carefully-controlled materials.

The contribution of such products to resource and energy efficiency can only be appreciated with a holistic approach that considers the complete lifecycle of the product, including its durability and impact over the use phase. This approach should also take into account all relevant environmental indicators, such as biodiversity, ecological and human toxicity and water use.

This holistic approach is required to ensure the responsible promotion of ceramic products made in the EU instead of less durable products or other ceramic products imported from less environmentally-regulated countries.

More than business as usual is necessary

The transition to a competitive low-carbon and resource-efficient economy in 2050 represents a challenging target for the European ceramic industry. As demonstrated in its long history, the sector is committed to contributing responsibly to the achievement of such a target. This enormous challenge means we need to build on our current know-how and expertise and new breakthrough technologies will be needed.

The 2050 emissions reduction targets are even more challenging for a capital-intensive sector with long investment cycles like ceramics. Kilns for ceramic production can last more than 40 years. Therefore, 2050 is less than the lifetime of a new kiln away. The model developed in this Roadmap shows that even in the hypothesis where half of all kilns are converted to electricity in the period 2030-2050 and the remainder retrofitted to syngas or biogas co-fired with natural gas, the emissions could only be reduced by around 78% compared to 1990 levels instead of the 83-87% industry target set by the European Commission, mainly due to unavoidable process emissions.

However, such a scenario will face significant technical, economic and resource constraints. Therefore, a supportive and reliable legal framework will be essential to mobilise the human and financial resources needed to acquire and implement the essential further breakthrough technologies.

Like many sectors, we operate in a global marketplace. Therefore, it is essential that the impact of EU legislation on the international competitiveness of the industry is properly addressed. In particular, climate policy needs a bottom-up approach which takes into account the technical and economic feasibility of additional emission reductions and also the level of regulatory commitment of non-EU countries.

Vision Statement

The European ceramic industry is a strategic enabler for growth, innovation and sustainability. Therefore, a thriving ceramic industry in the EU is vital to achieve a competitive low-carbon and resource-efficient economy by 2050.

The year 2050 is the target of several Roadmaps published by the European Commission which set long-term strategies for a competitive low-carbon economy, resource efficiency, energy and transport. All of these are key EU policy areas.

The debate following the publication of these documents has inspired a thoughtful discussion among Cerame-Unie's members on the current and future role of our industry in EU society. The Ceramic Industry Roadmap represents our contribution to that debate.

In this Roadmap, we take you on a tour of the ceramic industry's diverse sectors and demonstrate the strategic role each of them plays in society and in enhancing life quality. We aim to present a realistic overview of an industry that has always been at the heart of European society and tradition and which continues to lead on the global stage.

Ceramic companies across Europe are taking steps to introduce energy-saving best practices, improve resource efficiency and move away from traditional energy sources. In addition, taking a lifecycle view of our products shows that they help achieve resource, water and energy savings for consumers and downstream user sectors.

With a long history behind them and global leadership, the European ceramic industry stands on solid foundations and is fit for 2050 and beyond. We can enhance the international competitiveness of our industry and adapt to the shifting regulatory landscape, provided that the appropriate regulatory framework is defined and implemented by policymakers at European and national level working closely with us.

This is no straight road but working together, we can pave the way for a better future for Europe, delivering on jobs and growth in a sustainable manner. Ceramics will continue to play an exciting and critical role in the 21st century in many novel applications.

Alain Delcourt
President, Cerame-Unie

Introduction

As Europe undergoes enormous internal change and aims to maintain its role as a global leader in innovation, the ceramic industry finds itself well-positioned to bridge the old world with the new. Built on a long European tradition, the ceramic industry quietly plays a major role in our daily lives and forms the cornerstone of Europe's rich cultural heritage.

Ceramic objects are among the greatest and earliest achievements of mankind. Part of human history since man learned to control fire and manipulate clay, today's ceramics incorporate design and innovation while continuing to meet our needs. For many ceramic sectors, design is a crucial aspect and innovation in design is the best way to compete in a global marketplace. Other ceramic sectors are key for the development of clean technologies because they are essential in the production processes of many other industries.

With **25% of production exported** outside the EU and a **positive trade balance of €3.7 billion**, the European ceramic industry is a global player. Providing over **200,000 jobs** in Europe, with an **annual production value of €28 billion**, this industry makes a substantial contribution to the European economy.

Given the strategic importance of many of the industry's products, a competitive climate is essential to maintain the industry's global position. European companies strive to be the most innovative worldwide. This is reflected in the significant R&D investments made within companies, as well as in the clusters of universities and research centres working in ceramics.

While manufacturing can account for up to 90% of some ceramic products' carbon footprint, the inherent energy savings during the use phase together with the durability of ceramic products give them longer lifespans over which time the environmental impact of the production phase is significantly reduced compared to other materials. So the total environmental impact is significantly lower than for many alternative materials.

The Three Ps

People

As a local employer, developing skilled and trained employees, the ceramic industry has long been reinvesting into the communities it serves. There is also a wider global role, whether enabling humanitarian assistance in emergency situations or through community projects like building health centres in emerging economies or teaching water conservation in the EU, the European ceramic industry strives to improve the communities it operates in.

Planet

By reinstating clay extraction sites and protecting biodiversity, the ceramic industry plays an important role in maintaining sustainable local communities. The ceramic industry is committed to reducing CO_2 emissions and wastewater and to recovering and recycling its materials whenever possible.

Profit

The ceramic industry is one of the industries where global leadership is still in Europe, with many of the top worldwide companies being headquartered in the EU. Given the strategic importance of many of its products, it is vital for the European economy to create a competitive climate to maintain this leading position.

Ceramics in Europe

Leading the way in innovation and technology, ceramic manufacturers from the EU-27 account for 23% of global ceramics production. With a production value in Europe of €28 billion, the leading Member States producing ceramics are Italy, Germany, Spain, France, the UK, Poland, Portugal and Austria. Ceramic manufacturing is present in virtually all EU Member States.

Almost 60% of jobs in the industry are related to the housing and construction sectors, sectors with an important historical legacy in many European countries and which continue to contribute positively to the local economy.

Housing and construction represented almost 55% of the ceramic industry's turnover in 2011 and supplies to other industries account for more than 30%.

The ceramic sector makes a positive contribution to the trade balance of the EU. Around **25% of EU-27 production** is sold outside the EU, representing a positive input to the balance of trade. **Total exports in 2011 were €7.2 billion** while imports were €3.5 billion. This trend is on the increase with 2011 exports increasing by 7.3% and imports decreasing by 5.9% compared to 2010.

At around 30%, energy remains one of the highest production costs in the European ceramic industry, where the energy mix is around 85% natural gas to 15% electricity. **Over 1,000 ceramic installations** are covered by the EU Emissions Trading Scheme (ETS), representing more than **10%** of all industrial installations covered by the scheme. However, the

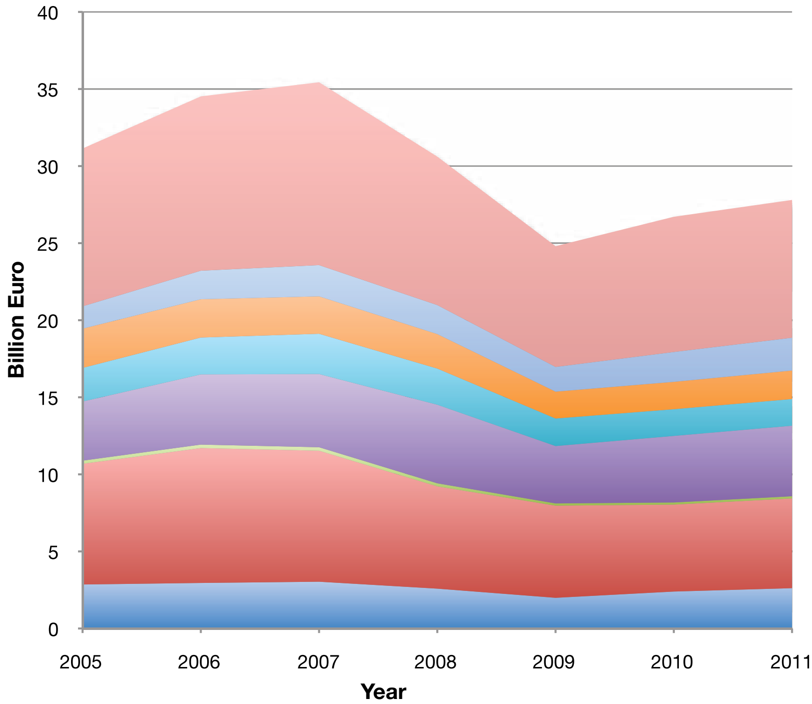


Fig. 1 - Annual production value 2005-2011 in the ceramic industrial sectors, Eurostat

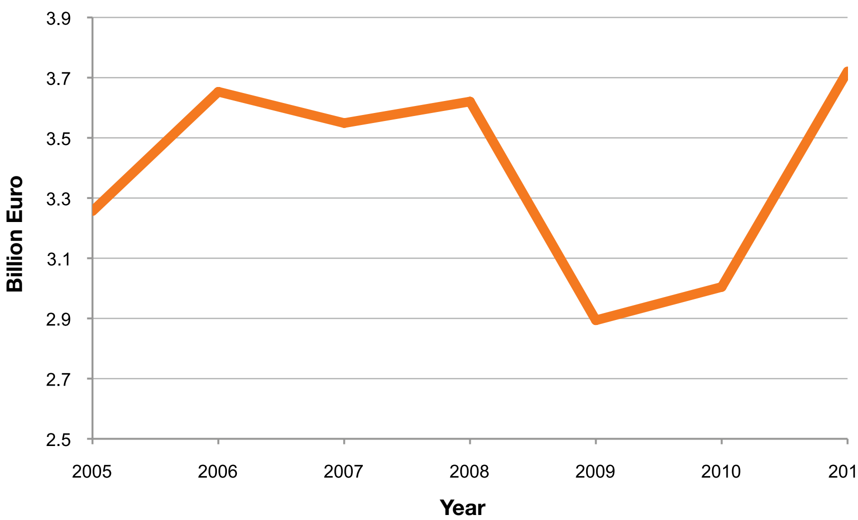


Fig. 2 - Total trade balance of the European ceramic industry 2005-2011, Comext, Eurostat

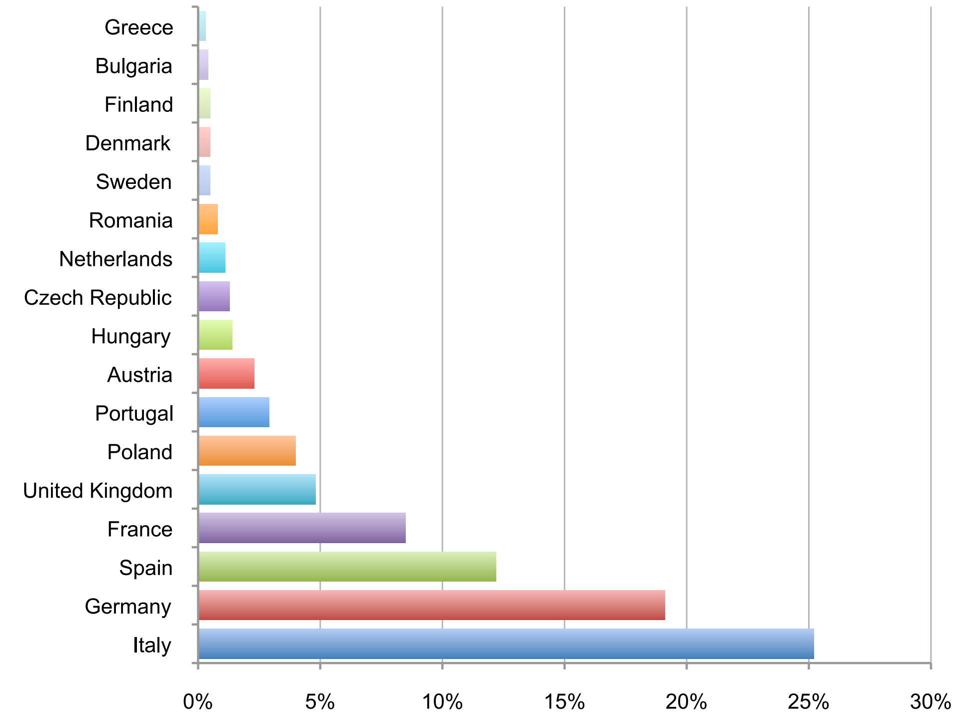


Fig. 3 - Percentage of production value by European country 2011, Prodcom, Eurostat

ceramic industry represents only **0.5%** of the total EU ETS CO_2 emissions. This is explained by the fact that more than 75% of ETS ceramic installations in Cerame-Unie's membership are classed as **'small emitters'** (with production of more than 75 t/day and emissions of less than 25 kt CO_2/year).

Some of the specific raw materials used for ceramics production such as high-grade magnesia, bauxite, silicon carbide and graphite are not readily-available in Europe. For parts of the industry, such as refractories, abrasives and technical ceramics, the main minerals have to be imported, mostly from Asia. **Rising prices of raw materials** from Asian countries, especially China, are starting to threaten markets where traditionally Europe has been a leader.

The European ceramic industry's international competitiveness depends on **effective trade policies** to counter tariff or non-tariff barriers, enforcement of intellectual property rights, protection against counterfeiting and dumped or subsidised imports. Moreover, its competitiveness relies on both the availability and the undistorted pricing of raw materials. Unfair trade measures by third countries, such as export quotas or export taxes, have serious impacts on European industry, creating artificial costs and putting EU importers at a considerable disadvantage.

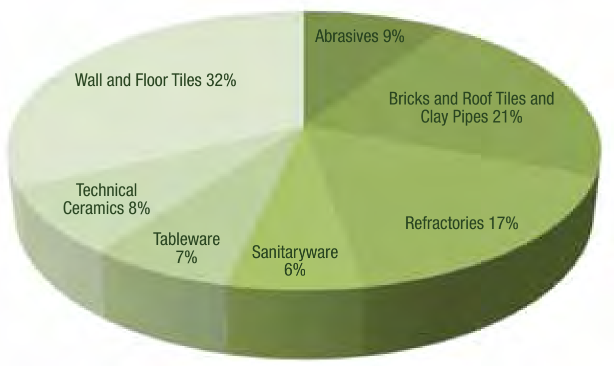


Fig. 4 - Percentage of production value of the ceramic industry in Europe by sector in 2011, Prodcom, Eurostat

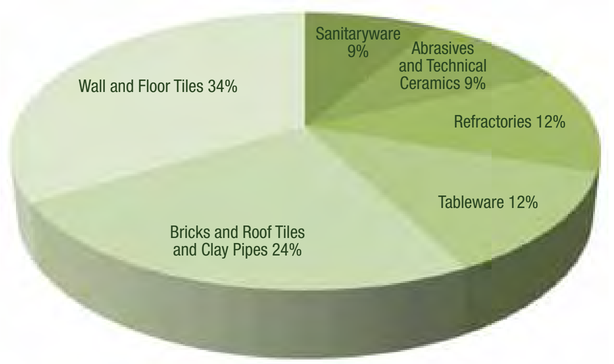


Fig. 5 - Percentage of employment in the European ceramic industry by sector in 2011, Cerame-Unie members' data. Total employment is 208,000 jobs in the EU-27

Raw Materials and Restoration

To ensure long-term raw material supply and to encourage ongoing investment in the sector, the extraction of clay and other minerals must be carefully planned. During and after extraction, quarries and riverbanks are restored and returned to their natural state, creating new habitats and promoting biodiversity. By restoring clay extraction sites and protecting biodiversity, the ceramic industry plays an important role in maintaining sustainable local communities.

A Closed Loop

Being inert due to the natural materials they are made from and the high-temperature firing they undergo, the majority of ceramics can be recycled and reused within the ceramics industry and by other industries. Many companies reprocess fired ceramic waste into new ceramic products. This creates an internal market for waste, which becomes a valuable resource and helps preserve natural stocks of virgin and important minerals in Europe such as clay, limestone and feldspar and also reduces the imports of minerals such as zircon, bauxite and magnesia from overseas.

Use Phase

One of the main advantages of ceramics is their durability. Ceramic products require very little maintenance, have high resistance to environmental conditions and are extremely cost-effective. Ceramics are essential as an application in construction and many other industrial sectors such as automotive, power generation, steel and concrete industries. Ceramic materials fulfil the demanding hygiene specifications, chemical and mechanical resistance required in our bathrooms. They also contribute significantly to improving the energy and environmental profile of those sectors' end-products.

Environment and Emissions

Energy Efficiency in Production

In the last two decades, significant reductions in energy consumption have been made during production, for example, through better kiln design and more efficient firing. Energy-saving innovations and materials technology have focused mainly on replacing solid fuel with natural gas, scaling up and improving the efficiency of kiln technology, and moving, where appropriate for the scale of operation, from intermittent (batch) to continuous (tunnel or fast-fire roller kiln) technology. The ceramic industry is continuously improving its energy efficiency where economically viable.

The energy used to produce the bricks for a **1m² brick wall decreased by 39%** from 1990 to 2007. For **one tonne of wall and floor tiles**, the energy used **decreased by 47%** from 1980 to 2003. By changing from a twice-fired process at conventional firing temperatures to a single firing process at reduced firing temperatures, one UK hotel tableware producer reduced emissions by 79% compared with similar products.

High-performing and durable ceramics must be fired at high temperatures. As such, the most energy-intensive process in ceramic manufacturing is kiln firing and in some cases the drying and shaping processes.

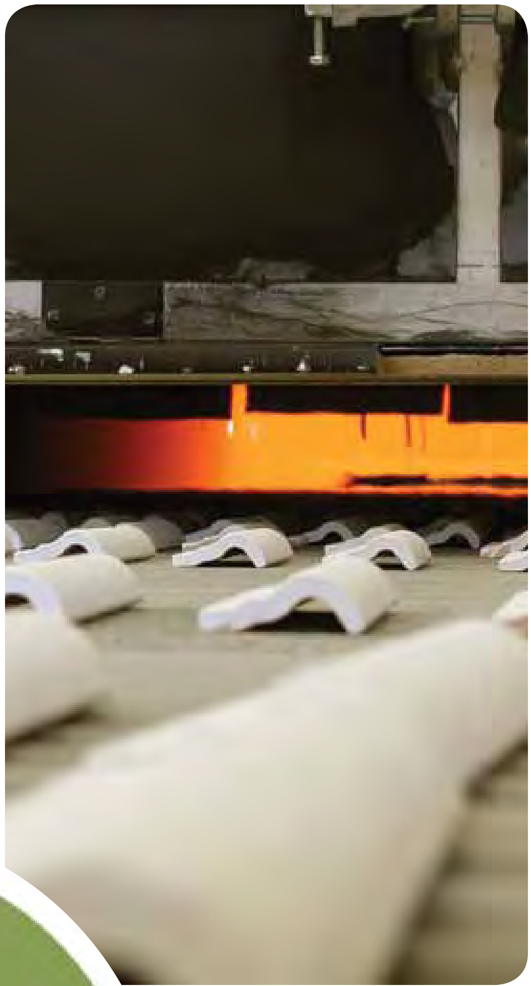
Erik Kjær, Chief Consultant, Danish Technological Institute, Denmark

"Back in the late 1960s, a large number of brick works in Denmark used coal as fuel for firing. Today, natural gas together with sawdust is the fuel for approximately 95% of brick production in Denmark. This has reduced CO_2 emissions by approximately 40-50%. Combined with the energy savings made in the production process, the total CO_2 emissions in the Danish brick industry today have been reduced by more than 75%."

Production

The production of ceramics varies according to the final product, but generally includes the preparation of raw materials, shaping, drying, glazing/decoration, firing and in some cases assembling. Investments like computer-controlled kilns, formulations with optimised firing temperatures and waste heat recovery systems improve energy efficiency. Transport and firing emissions have been further reduced by technological advances leading to significant weight reduction.

Carbon Dioxide Emissions



The bricks and roof tiles, refractories and wall and floor tiles sectors together emitted a total of 19 Mt CO_2 in 2010. Of these emissions, 66% were due to fuel combustion, with electricity and process emissions accounting for 18% and 16% respectively. Existing best available technologies (BAT) are continually-improving, but breakthrough technologies need to be developed in the near future.

Fuel Emissions

Energy efficiency is the most obvious way to reduce fuel emissions. Energy consumption can be further reduced if improved kilns, dryers, thermostats and seals are installed and by implementing automated controls. Heat savings can be achieved by improving thermal insulation through the use of novel refractory linings, coatings and other ceramic materials. As the life of a kiln can be more than 40 years and represents major capital investment, it is not financially-feasible to routinely upgrade kilns before the end of their life and replace them with more energy-efficient models.

Recovery of excess heat is also widespread as it reduces fuel consumption. This can be done by capturing kiln gases in order to preheat the combustion or dryer air. Smart design of manufacturing facilities is also a key factor because the physical distance between the different processes, e.g. firing and drying, can account for energy savings.

Electrification of kilns using low-carbon electricity could be an option to reduce fuel emissions, particularly for large kilns making bricks, roof tiles, wall and floor tiles. However, this option is not currently economically-viable due to the significantly higher cost of power compared to natural gas.

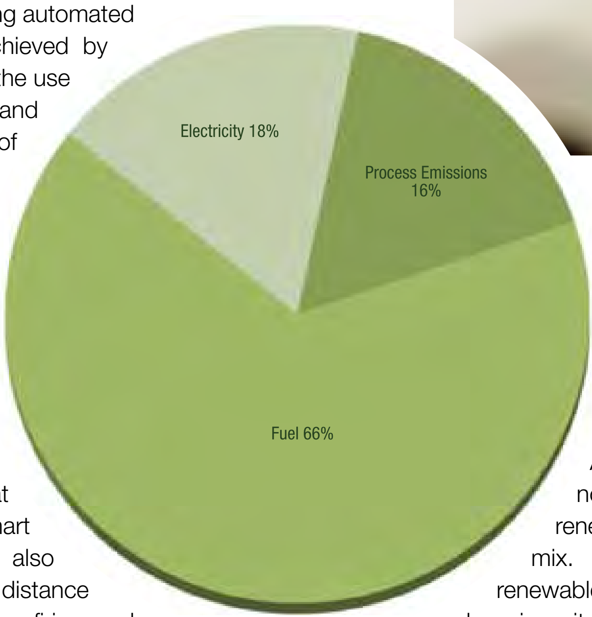


Fig. 6 - CO_2 emitted during 2010 aggregated for the bricks and roof tiles, refractories and wall and floor tiles sectors (total emissions of 19 Mt, representing approximately of 90% of total ceramic industry emissions). The proportion between different emission types, particularly for process emissions, can vary significantly between different processes and factories

Alternative Energy Sources

The continuous processes used in the ceramic industries all require uninterrupted, secure and affordable fuel and electricity supplies as unplanned interruptions can cause severe kiln damage resulting in shutdown and production loss for several months.

The ceramic industry predominantly uses natural gas as it is more energy-efficient at the high temperatures required to fire clay and other industrial minerals. Today, diesel, LPG, coal or coke are only used when mains gas is unavailable.

Across Europe, companies are now integrating alternative fuels and renewable electricity into their energy mix. Several countries have started using renewable energy for some brick, roof tile and clay pipe sites, but have encountered difficulties in obtaining planning permission for some of these installations, particularly for wind turbines and energy from waste projects. Therefore, a favourable legal framework is essential for waste to energy projects.

Cogeneration has developed in Member States where there are clear regulatory incentives for combined heat and power (CHP) generation. In 2012, there were around 250 CHP plants mainly in Italy, Portugal and Spain with an average installed capacity of 3MW. Many are micro-generation facilities with less than 1MW capacity. By producing electricity in addition to the heat necessary for its low to medium-temperature needs, the ceramic industry contributes to the overall energy efficiency of these Member States.

In the region of Valencia, which is home to 95% of Spain's ceramic tile industry, some ceramic factories have solar panels. The Almeria Solar Platform, in Andalucia in Spain, is doing research into solar ovens which could reach high enough temperatures for drying ceramics, e.g. 200-300°C. Work is ongoing into high-temperature ovens which could even fire some ceramics.

For high-temperature firing, the most promising way to reduce fuel emissions is to replace natural gas by biogas or syngas from biomass or waste, modifying existing kilns through retrofitting.

However, biogas today is very expensive, currently 2-3 times the price of natural gas. Syngas produced by the gasification of organic waste or biomass also has a higher potential to replace natural gas and significantly reduce emissions, particularly in the brick and roof tile sectors. On average, the kiln represents 80% of the natural gas consumption of a clay production unit. Substitution rates of up to 80% syngas could technically be possible in some plants, with a potential reduction of running costs. This could reduce CO_2 emissions by over 30%.

The future European public-private-partnership of the process industries (SPIRE) will be essential for the development of this promising technology that has yet to achieve full industrial reliability. Securing reliable, economic and sustainably-produced biomass or long-term waste supplies is of equal importance.

Process Emissions

Carbon dioxide emissions are not only related to energy consumption, e.g. fuel-related emissions, but also to process emissions. Process emissions are carbon dioxide emissions caused by the breakdown of carbonates in raw materials such as limestone, dolomite or magnesite. As these are inherent in the raw material, these process emissions are a natural by-product of the firing process and cannot be avoided.

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 and consequently higher CO_2 emissions. As such, it would not be environmentally-sound to relocate factories and jobs to reduce process emissions.

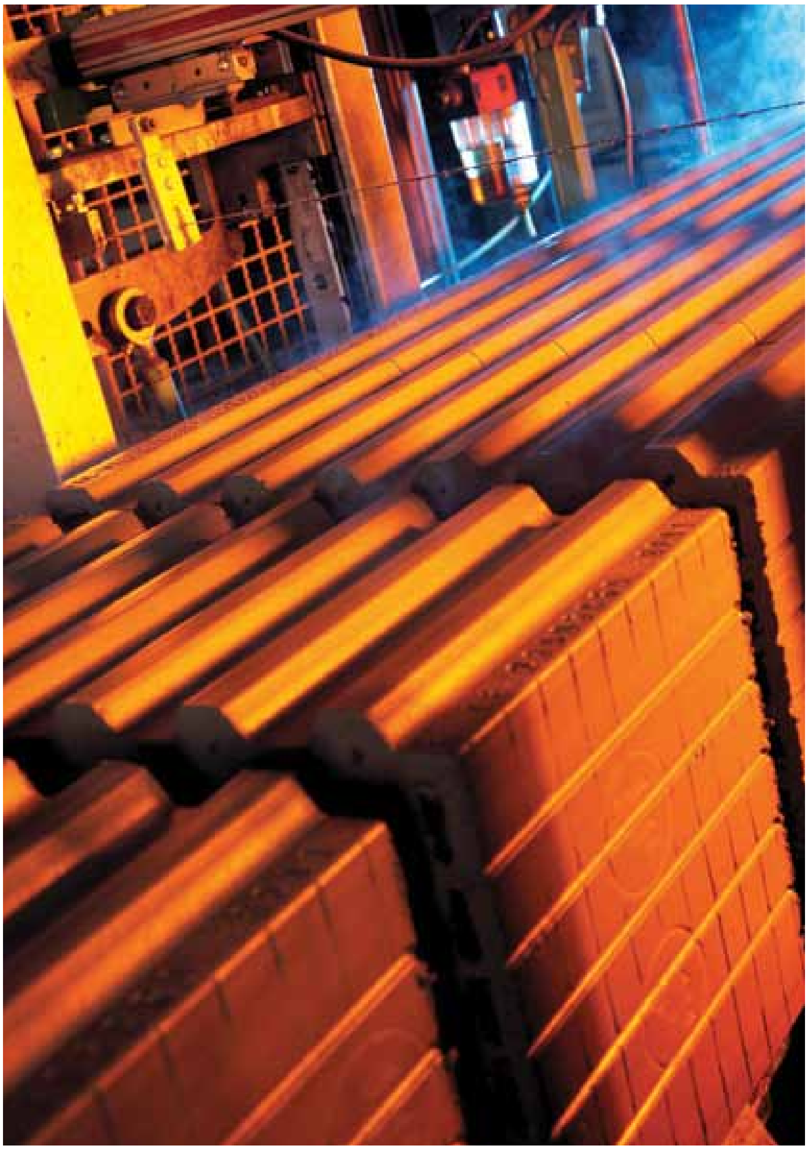
CCS

Carbon Capture and Storage (CCS) could be a solution to reduce CO_2 emissions in some sectors. However, ceramic factories are more numerous, smaller in size and more widely-dispersed geographically than, for example, those in the steel and cement sectors. The exhaust stream from ceramic plants is too CO_2 dilute, too hot and contains too many other substances for efficient, cost-effective CCS at present. 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 it is installed in other energy-intensive sectors.

Emissions Related to Electricity Consumption

The ceramic industry is not classed under the EU ETS as electro-intensive so it does not benefit from any electricity pass-through compensation. For some of the high-temperature processes in the refractories and technical ceramics sectors, such as electric arc furnaces and electric induction furnaces operating above 2000°C, there is a significant risk of carbon leakage outside Europe.

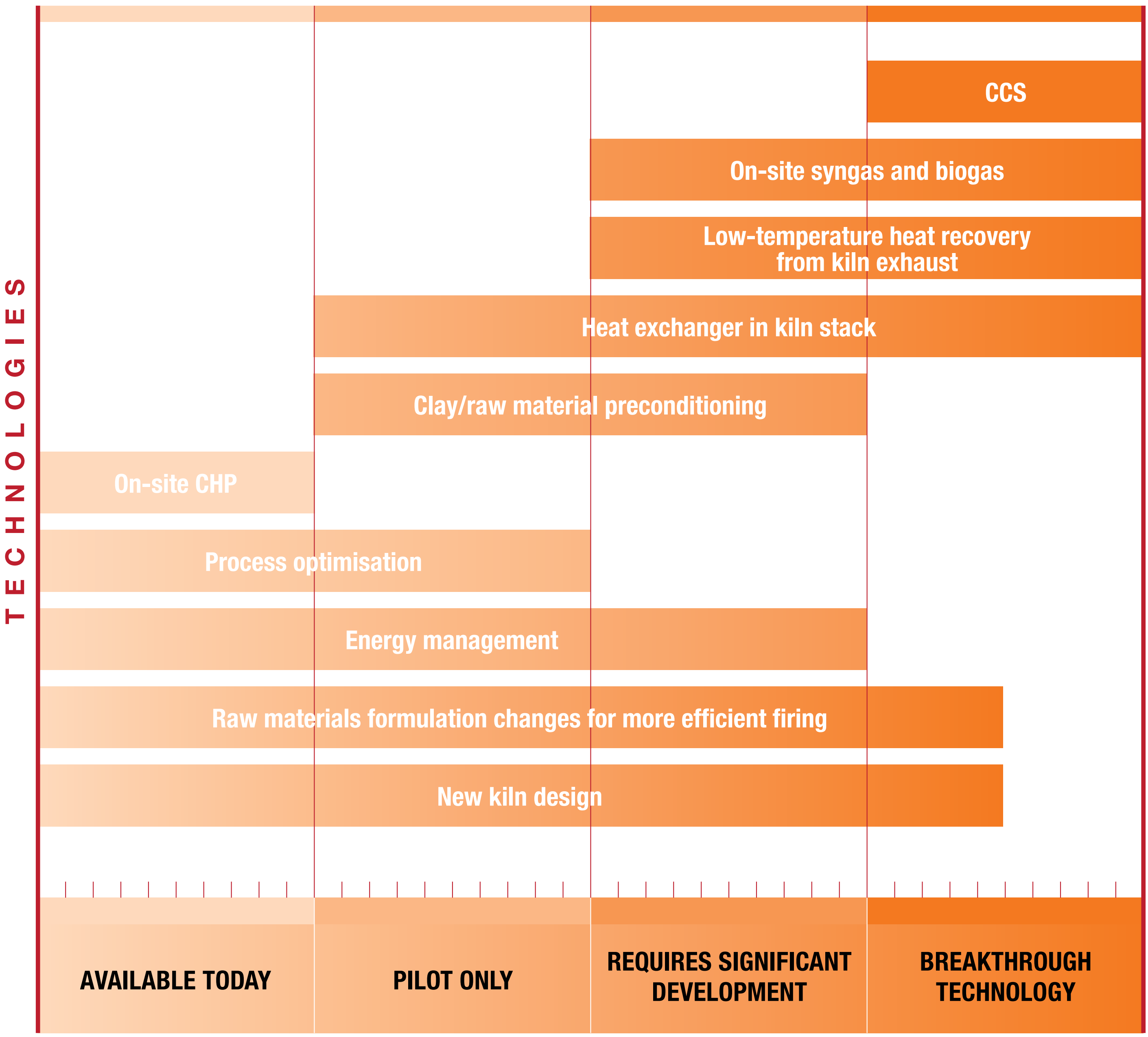
However, the electro-intensity of the ceramic sector is expected to rise towards 2050 as some processes may shift from gas to electric firing. Moreover, increasing demands under the EU Industrial Emissions Directive and other legislation may require more use of electrically-powered equipment. Therefore, some ceramic sectors will have significantly more electricity usage and may therefore become vulnerable to job and carbon leakage as they are highly-exposed to international trade.



Current and Future Technologies

Figure 7 presents an analysis of some of the key technologies which could be applied across the ceramic industry, highlighting both present availability and future developments and taking into account cost-effectiveness and the probability of their success in reducing emissions. Breakthrough technologies that are known today but still require further development are also presented as they could significantly reduce emissions in the near future if proven. Some technologies such as on-site syngas and biogas, on-site CHP and CCS, will also require significant support from regulators and/or face supply challenges which are outside the industry's control.

Fig. 7 - Analysis of key technologies which could be applied across the ceramic industry



Emissions Reduction Model

The push to decarbonise electricity in Europe will reduce the ceramic industry's indirect emissions from electricity, but will not be sufficient to adequately decrease its emissions by 2050. Most emissions in ceramic production arise from fuel and more radical steps and breakthrough technologies are required. There also remains the major challenge of process emissions reduction in some sectors. The cost of adaptation will significantly affect the global competitiveness of the ceramic industry.

As part of this Roadmap, Cerame-Unie developed an emissions reduction model to illustrate the possible emissions reductions between 1990 and 2050. This is based on real emissions data from the bricks, roof tiles, wall and floor tiles and refractories sectors which together comprise approximately 90% of the entire ceramic sector's emissions.

According to this model, the EU ceramic industry can only achieve emissions reductions close to the political targets for the EU industry with breakthrough technologies, secure alternative fuel sources and financial assistance. This is because there is an unavoidable energy input to produce durable ceramics.

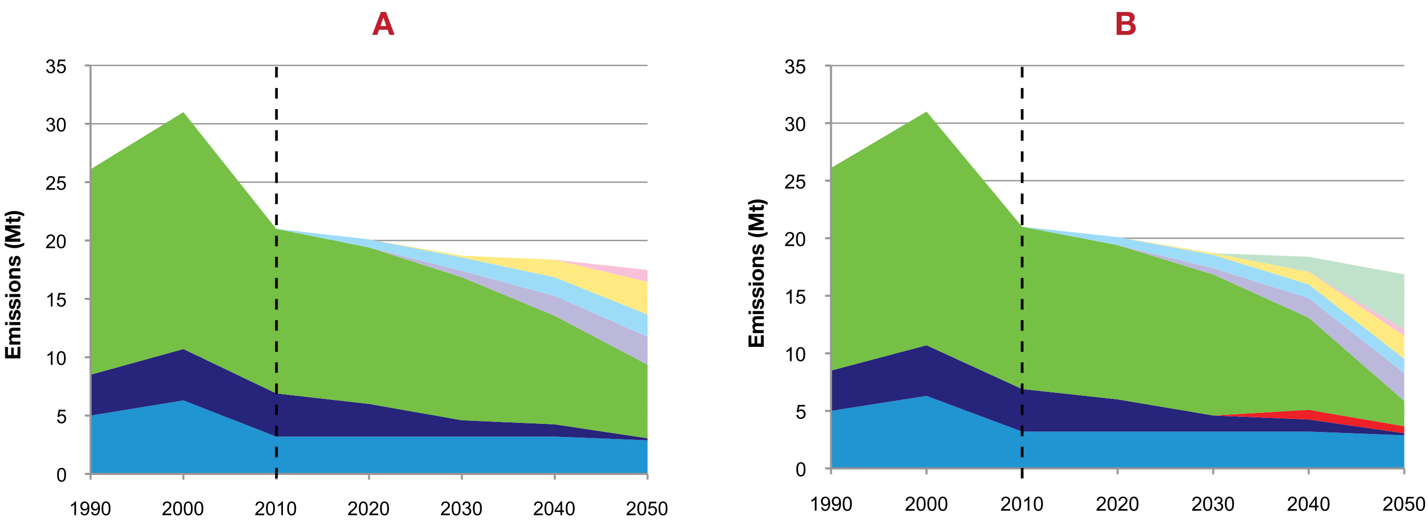
Sources of CO_2 Emissions:	Sources of CO_2 Emissions Reductions:
Fuel	Kiln electrification
Extra electricity from kiln electrification	CCS
Electricity	Other identified breakthrough technologies
Process	Available technologies
	Breakthrough technology syngas/biogas

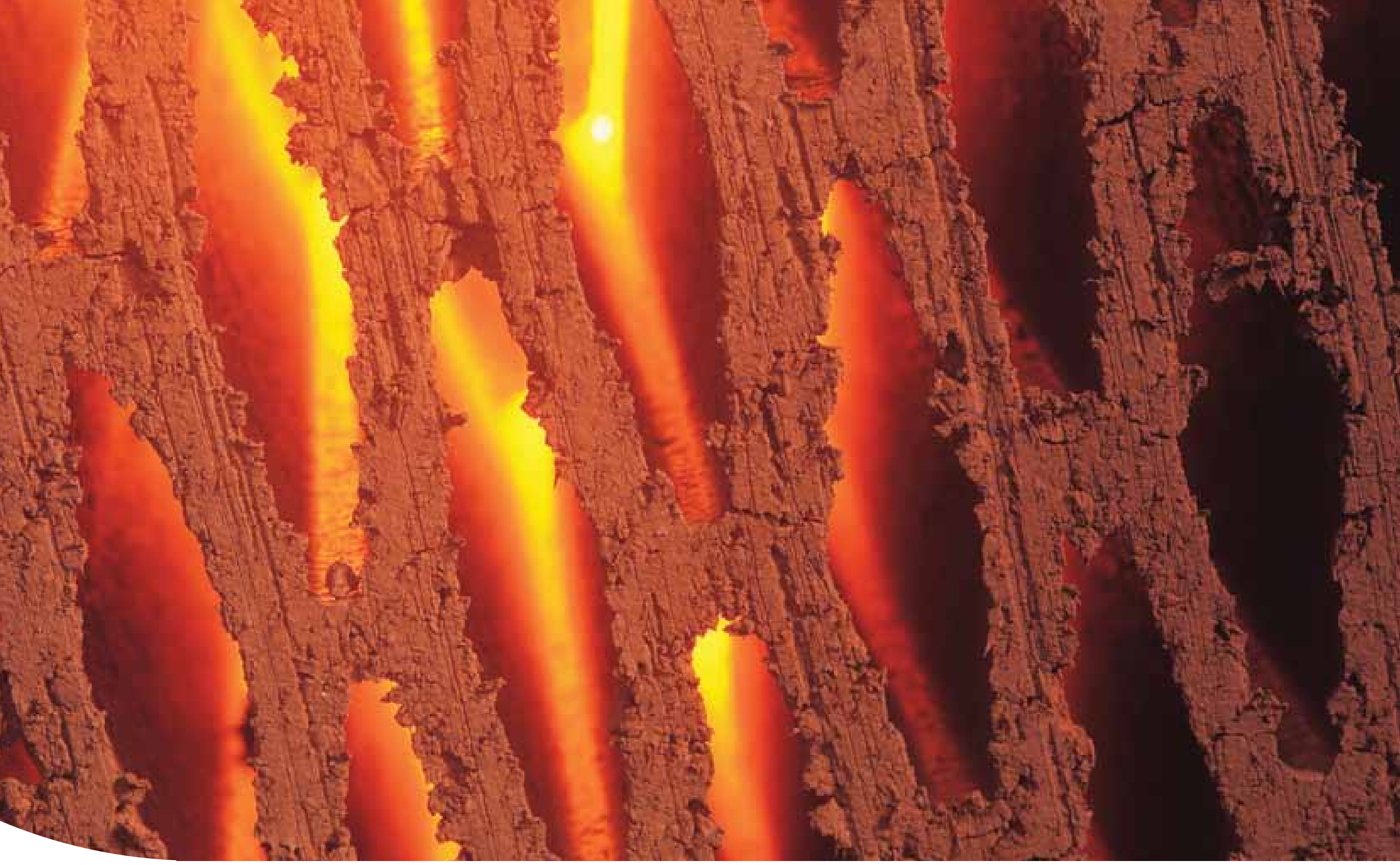
There are additional challenges such as the fact that fossil fuels are currently used as the industry's main energy source. Finally, in the vast majority of cases, process emissions are unavoidable. Only a technology such as Carbon Capture and Storage (CCS) could reduce process emissions but it is technically more challenging and less economically-viable than for many other sectors.

The Cerame-Unie emissions reduction model assumes a constant level of production between 2010 and 2050 with a similar product mix and that the emissions are for constant and near-full kiln load and production levels. It should also be noted that the lower 2010 level of production is affected by the consequences of the economic crisis.

This model illustrates how emissions could be reduced by up to **65%** between 1990 and 2050,

*Fig. 8 - Illustrative model for CO_2 emissions reduction between 1990 and 2050: **A**) excluding and **B**) including kiln electrification. Before 2010, emissions are estimated based on the real production level between 1990-2010*





based on an analysis of current and identified future technologies and assuming that all barriers regarding alternative fuels are overcome. This would also mean that regulators treat syngas and biogas as producing net zero emissions.

Even in the hypothesis where half of all kilns are converted to electric kilns in the period 2030-2050, and the remainder to syngas or biogas co-fired with natural gas, the emissions could only be reduced by 78% compared with 1990 levels, mainly because of unavoidable process emissions.

This scenario would be an extremely costly step for both capital and running costs. Under these circumstances, the European ceramic industry could not remain financially-viable and internationally-competitive. The capital cost of this option will be approximately €90 billion, assuming breakthrough technologies in electric kiln efficiency, the development of which will imply significant further costs. In addition, we estimate a cost of up to €40 billion for writing off plants before the end of their life and lost sales during downtime for plant modifications. Furthermore, the energy bill for a typical tile factory will most likely increase to about 2.5 times the current rate and the cost of biogas will be 2-3 times that of natural gas, even at current prices.

Research and development may create opportunities for further emissions reductions across the ceramic industry through breakthrough technologies which are not known today and have not been modelled here.

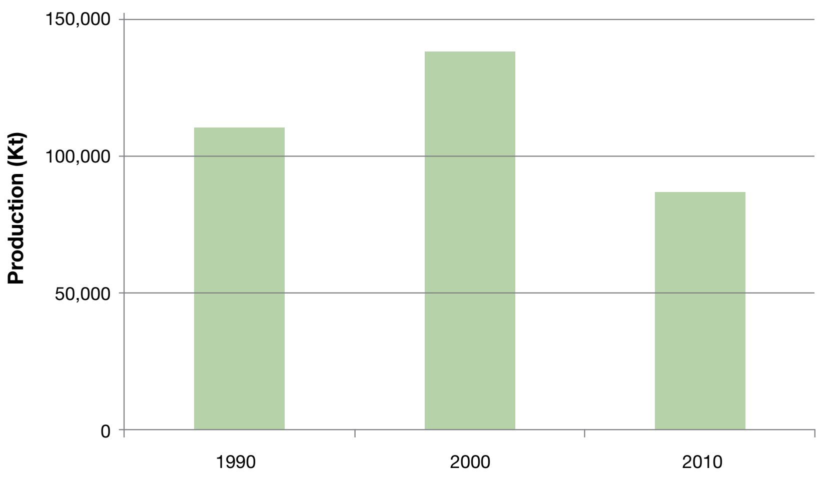


Fig. 9 - Production of refractories, wall and floor tiles and bricks and roof tiles sectors in the last 20 years

Ceramic Durability and Energy Savings

When assessing the impact and contribution of ceramic products, we need to look beyond the production phase. The long lifecycle of ceramic products shows how the durability, heat resistance and other properties of ceramics contribute to energy and resource efficiency over the entire lifetime of the product in other sectors and during the use phase of other applications. In everyday life, ceramics make a significant contribution to residential energy savings. The application of ventilated facades and insulating blocks assure thermal stability in buildings, providing significant savings for heating and cooling. Ventilated facades can increase the energy efficiency of a building by 40%. Innovative solutions also include new high thermal insulating clay blocks, which can also be filled with mineral wool, perlite or polystyrene and roof tiles with integrated photovoltaic cells.

In the EU-27, there are approximately 20 billion square metres of residential homes. The average heat and energy losses in residences with deficient wall insulation are significant. Replacement at a rate of 1% per year with appropriate products such as thermal insulating clay blocks or ventilated cavity walls with clay facades could result in saving 100 million tonnes CO_2 by 2050.

Ceramic products are built to last and durability is one of their key benefits compared to many other materials. Studies show the average life of a brick house is more than 150 years. Vitrified clay pipes can also last for more than 150 years. In flooring, the expected lifecycle of porcelain, ceramic and mosaic tile is 50 years, far longer than carpet, vinyl or natural hardwood.

Innovations in refractories, abrasives and technical ceramics also contribute to significant energy and resource efficiency in other sectors and applications during the use phase, multiplying significantly their positive impact.

In recent decades, the quality and lifetime of refractories has increased. Fewer refractories are now needed: today just 10kg per tonne of steel compared to 50kg in 1990. As a result, the emissions per tonne of steel reduced 77% over this period. To give an example, 3.15 million tonnes of CO_2 have already been saved in the annual production of cars due to the use of refractories. Refractories also improve the properties of the steel itself, for example by enabling the production of lightweight steel. Precision grinding by finer abrasives further improve engine efficiency. Hence, the overall reduction of CO_2 emissions in the transport sector will be even higher.

Water Conservation

During manufacturing, water is used in many ways including as a raw material, heat exchange vehicle and cleaning agent. Often the water supply includes recycled water, rainwater harvesting schemes and recycled water from on-site lagoons and boreholes. Water is recycled in many ceramic plants, often using ceramic filters. Most companies in the sanitaryware and tile sectors reuse their wastewater and almost all of the production and purification waste is reused in the production cycle. All over Europe, companies use rainwater to reduce water consumption and many ceramic producers have their own wastewater treatment plants.

Due to developments in the sanitaryware sector, the water consumption in homes has decreased dramatically in the last two decades through the introduction of new toilet and flushing mechanism designs. More than 30% of the water used in homes is for toilet flushing and today all new toilets are equipped with dual flushes, discharging less than 6 or 3 litres compared to earlier models which have a 9 litre single flush only.

Recycling

Innovation and ingenuity continually add new materials to the ceramic industry's growing portfolio of products. Brick can be crushed into brick chips and used for landscaping or as a raw material for other products. In some British ceramic companies, up to 20% of total material usage in production is from alternative, recycled and secondary source materials, with 200,000 tonnes of clay being replaced in one year by materials that would otherwise have been scrapped. Unfired clay can be reused and imperfect fired bricks are crushed and used as aggregates in the construction industry.

Bricks and roof tiles are recycled throughout Europe. Building and demolition waste including waste ceramics and plaster moulds used in some processes are used extensively in road construction and as a secondary aggregate, while wall and floor tiles contain more recycled material. In the refractory industry, 20% of used refractories are again recycled into refractory applications, 27% are reused in non-refractory applications, 35% are dissolved during use and only 18% remain as unusable waste.

Applications

Construction and Housing

General Benefits

Ceramic-based building materials have an average service life of over a century and boast excellent resource efficiency at all lifecycle stages. Their durability supports the optimisation of a raw material with many advantages for the construction and housing sectors.

The unique properties of ceramics provide improved energy efficiency and thermal comfort in both warm and cold, humid and drier climatic conditions, while their resilience to corrosion and versatility across hundreds of applications ensures that ceramics will maintain their fundamental role in the housing and construction sectors.

Bricks and Roof Tiles

The production of bricks and roof tiles is one of the most well-known applications of ceramics. Bricks and roof tiles have been used for centuries because of their proven ability to protect homes from the elements. As an inert product made from natural materials, ceramic tiles and bricks are non-toxic and do not emit volatile organic compounds (VOCs), complying with the VOC restrictions in the Leadership in Energy and Environmental Design (LEED) Building Certification and providing a healthy indoor climate. Ideal for sustainable housing, bricks are highly-resistant to fire and provide insulation from sound and vibrations, electricity, electrostatic and ionising radiation.

Timo Leukefeld, Prof. Dipl.-Ing. and energy expert at Energie Verbindet, Germany

"Monolithic external clay block walls, made from special high-tech clay products, provide a comfortable thermal indoor climate, both in winter and in summer. The result is complete energy independence for the building, without needing energy from fossil fuels or electricity from the grid."

Wall and Floor Tiles

Moulded in an endless number of designs and formats, wall and floor ceramic tiles build on 2,000 years of tradition to provide durability, aesthetics and technical solutions in private and public buildings. No longer just a decorative feature inside homes, wall and floor tiles have become indispensable in the provision of hygiene. A new generation of coatings with photocatalytic properties (activated by UV radiation) gives tiles the ability to destroy organic matter that settles on their surface and encourages water to slide off, while antibacterial tiles with light-activated antibacterial surface coatings kill hospital bacteria such as MRSA and other disease-causing pathogens.

Other recent innovations include new forms of ceramic sheeting, including fibre-reinforced ceramics, ceramic composites containing conductive layers for heating systems, inner porous layers for thermal and acoustic insulation, and strong, lightweight thin tiles that minimise the tiles' environmental impact.

Vitrified Clay Drainage Pipes

An essential part of municipal infrastructure, vitrified clay pipes transport wastewater safely and effectively away from buildings and roads and on to treatment plants. The raw material used in clay pipe production is a completely natural, inert resource and is available in virtually unlimited reserves. Vitrified clay remains inert even when subjected to extreme temperatures or chemical attack and when it is eventually taken out of service, it is completely recyclable. Currently up to 27% of the raw material used in vitrified clay pipe production comes from recycled clay products.

Sanitaryware

Favoured by architects and interior designers, ceramic washbasins, toilets, bidets and shower trays are found in homes and buildings the world over. Increasingly innovative designs in the sanitaryware sector mean that ceramics can offer a huge range of products covering nearly every kind of application requested by the market. Ceramics' light resistance ensures that ceramic sanitaryware does not fade or age, while the glazing process delivers smooth, easy cleaning surfaces, low water-absorption, optimal hygienic characteristics and assures the indoor air quality of bathrooms. Ceramic sanitaryware has made a huge contribution to the reduction of disease in general and a dramatic reduction in the water consumption of household appliances.

Roberto Palomba, interior designer, Italy, and Klaus Leuschel, designer and author, Germany

Award-winning architect and interior designer Roberto Palomba is clear about his preference for ceramic bathroom materials, noting that "Ceramics satisfy virtually all demands placed on a bathroom material - better than any other." Looking at ceramics from an art historian's angle, author Klaus Leuschel describes ceramics as "original, authentic materials. Their properties and appearance have a positive image deep in people's psyches."

A SUSTAINABLE FUTURE

As the world's population rises, ceramics are being developed to meet the growing demand for affordable, energy-efficient and sustainable housing in Europe and beyond. The brick and roof tile houses of tomorrow will continue to build on their legacy to meet the demand for sustainable solutions. Energy-efficient buildings such as the 'zero energy house' concept have opened new possibilities for sustainable construction with bricks and roof tiles.

Innovative model houses built with high-thermal, energy-efficient, integrated insulation clay block envelopes deliver significant energy savings and meet the requirements of the EU's Directive 2010/31/EU on the energy performance of buildings for 2020. 'Cool roofs' using brightly-coloured roof tiles reduce the internal temperature in attics and houses in regions with warmer climates and provide comfort in summer without using energy-intensive cooling systems.

Shaping techniques based on the continuous compaction of powders hold enormous potential for the future of low-carbon, ceramic-based floor coverings and substrates for building facades. The manufacturing process behind these products allows multi-layered slabs and composite materials to be made from recycled powders, contributing to cost savings and improved energy efficiency in the built environment.

Ceramic sanitaryware producers are constantly developing innovative water-saving solutions, such as flushless urinals, shallow-depth washbasins and water-efficient toilets and cisterns.

Communities are witnessing the introduction of 'intelligent ceramics'- a sustainable cities concept where ceramic applications such as flooring can improve the accessibility, comfort and safety of citizens, preserve and regenerate the urban environment and reduce maintenance costs for public spaces and buildings. Sensors built into ceramic flooring can detect human presence and activate traffic signals, while wall tiling integrated with heating systems prevent snow and ice from building up at transport hubs. Advanced ceramics hold enormous developmental potential for global resource-efficient solutions.

Industrial Applications

General Benefits

The ability of ceramics to withstand extremely high temperatures, as well as their durability, strength and non-corrosive properties make them essential for a number of specific applications required in metallurgical processes, glass production and many other key processes across all industries. Gears used for steelmaking or quarrying often include advanced ceramics because their wear, corrosion and thermal resistance offer significantly longer life compared to conventional metal gears.

Abrasives

Abrasives comprise a small but indispensable industry. Much of the complex machinery required by industries, as well as the smooth finishes in countless applications, from diamonds, watches and furniture to kitchen appliances and aircraft, is ground, cut, drilled or polished with abrasives. The European abrasives industry significantly impacts productivity in other industrial and services sectors, including steel, metal processing, automobile manufacturing, space, glass, construction, stone processing, shipbuilding, cleantech, machine-building, wood processing and defence industries. Maintaining and developing the abrasives industry in Europe will ensure the independence of Europe's industrial production.

Of the wide variety of abrasives, 10% are made from ceramic processes, the rest being made by different technologies from coating paper and textiles to organic bonded products, pastes or diamond coatings on steel blades.

Dr Wolfgang Eder, CEO VoestAlpine, President Eurofer, the European Steel Association

"Refractory products are indispensable for steel production. Thanks to innovations in the use of refractories today, such as ultra high power electric arc furnaces, the steel industry has made significant advances in recent decades, both in terms of productivity, quality, reliability and environmental performance. Looking to the future, we expect to continue counting on the strong performance and reliability of the European refractory industry to help us further the competitiveness of the steel industry in Europe."

Refractories

Refractories are essential for all high-temperature industrial processes. They play the triple role of providing mechanical strength, protection against corrosion and thermal insulation. The lining of every single reactor, transport vessel or kiln uses a wide range of refractory products including bricks, monolithics and high-temperature insulation wool. Refractory products are adapted to each specific application through fine-tuning and a careful choice of the different raw materials and their processing. Innovative refractory products provide resource-efficient solutions to downstream industries and have been instrumental in the development of key breakthrough processes such as the continuous casting of steel or the production of float glass. And last but not least, refractories are also indispensable as kiln linings or physical support during the firing of all ceramic products.

The functionalities of technical ceramics and refractories meet critical needs in steel, aluminium, cement, glass, the chemical industry and environmental applications as well as for energy generation, all of which create some of the most corrosive high-temperature environments in industry today. They take advantage of the improved energy efficiency, productivity and metal quality that refractories and technical ceramics bring to handling smelting, melting and molten materials processes.

A SUSTAINABLE FUTURE

A more efficient use of resources has become the key element in allowing industry to develop in a sustainable way, meeting the expectations of future generations and the low-carbon economy. Improving energy efficiency, reducing inputs and reliance on increasingly scarce raw materials, minimising waste, reducing the amount of refractories consumed by downstream industries and increasing recycling are some of the solutions European refractory companies are contributing to.

Abrasives, technical ceramics and refractories are essential solution providers that improve resource efficiency in the supply chain. Finer abrasives and superabrasives enable precision grinding for improved engine efficiency and thus lower vehicle emissions. Innovative abrasives also reduce rework and scrap by enabling cooler cutting and reducing heating and waste during industrial processes. This results in fewer stress fractures in critical components, reinforcing them with longer life, reduced weight and enhanced performance in many applications, particularly in the aerospace, automotive and defence sectors.

Innovative refractories and other ceramics also play a key role in the development of clean technologies. Ceramics contribute to low-carbon energy generation and electricity distribution. In the recent European Commission report, ‘Materials Roadmap Enabling Low Carbon Energy Technologies’, ceramic components were acknowledged to be critical in most technology options, with applications in the production of low-carbon technologies.

Consumer Goods

General Benefits

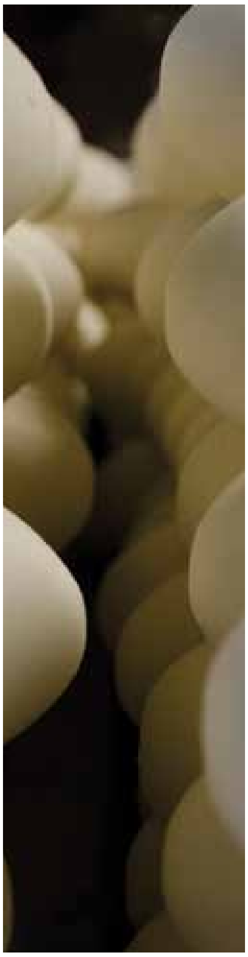
Ubiquitous in consumer goods, ceramics present a natural, affordable and long-lasting choice of raw materials whose transformation into an array of consumer goods is achieved with minimal environmental impact.

The complex chemistry of many ceramics facilitates their use at high temperatures and their robustness in coping with high speeds during manufacturing processes. Unique properties such as high resistance to abrasion, chemical inertness and dimensional stability ensure that ceramics today have the longer life and lower maintenance costs required to maintain the pace of technological advances.

Tableware and Ornamentalware

Ceramic table and ornamentalware, whether made of porcelain, stoneware or earthenware, have long been part of our culinary rituals. Fired in kilns using abundant natural resources like clay and sand to create these stone-like substances, ceramics have had an astonishing legacy throughout history, providing civilisation with as many varieties as there are cultures and cuisines.

From the vases, utensils and carrying vessels of yesteryear to the dinnerware, fine chinaware and hotel porcelain of today, the natural longevity of ceramics ensures that they will continue to evolve with the times and remain the primary vessel of choice for serving food.



Stephan Härdi, Executive Head Chef, Radisson Blu Plaza Hotel, Norway

"We have been working with high-end porcelain products since 2004. As a market-leading hotel and Food and Beverage operation, we are benefitting greatly from the unique but practical shapes and concepts available today and the ongoing cost savings resulting from the tremendous durability of these porcelain-vitrified hotel products."

Household Appliances

The ability of ceramics to withstand very high temperatures makes them ideal materials for cooking and heating appliances. Ceramic-coated frying pans are a common replacement for other, more controversial non-stick coatings.

Ceramic water filters provide safe drinking water to millions of people all over the world. The small, complex pore structure of ceramics provides genuine sub-micron filtration. These filters are relied upon in the most demanding situations like war zones and natural disasters.

A SUSTAINABLE FUTURE

Dining sets and ceramic art are passed from generation to generation as part of our culture. Safer cookware and standalone water filters that provide clean drinking water in developing communities are all examples of the future of ceramics in consumer goods. As water becomes a more scarce resource, ceramic water filtration and liquid cleansing solutions will become more widely used both in Europe and in developing countries.

High-Tech and Innovation

General Benefits

Ceramics have become indispensable in cutting-edge technologies. Advanced technical ceramics have unique mechanical, electrical, thermal and biochemical properties that enable their use in a variety of applications in the automotive industry, electronics, medical technology, energy and environment and in general equipment and mechanical engineering.

Technical Ceramics in Healthcare

Medical, laboratory and pharmaceutical instruments as well as ceramic components are used extensively in healthcare, in blanks for the production of crowns, bridges and implants in dentistry and also in implantable medical devices such as pacemakers or hip replacements.

Due to their biocompatibility, wear resistance and chemical and corrosion resistance, ceramic biomedical implants are the optimum solution for problems arising from disease, infections and other complications.

With low allergenic potential, ceramic components are also well-suited for patients with metal allergies. Innovations in highly-advanced medical-grade ceramic applications continue to deliver improved performance in healthcare.

Technical Ceramics in Electronics

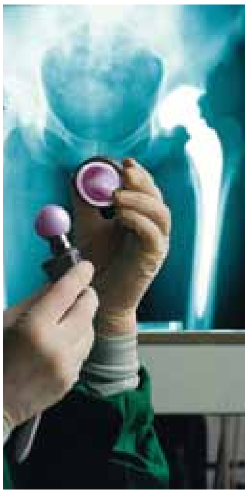
Ceramic substrates, circuit carriers, core materials and many other components are in use throughout the electronics industry. Ceramic heat-sinks provide the perfect climate for high-power electronics, while ceramics' electrical insulation properties mean they are used in microchips, circuit boards and circuit breaker technology.

In addition, piezoelectric ceramic components, electromechanical transducers that convert mechanical energy into electrical energy, are used in sensors, actuators, gas ignition and power transducers for high-power ultrasonic applications, such as transmitters and receivers in signal and information processing.

Combined with other unique properties, ceramic components are found in a wide range of demanding applications that ensure reliable functioning in aerospace technology, the automotive industry and optoelectronics. Ceramics help keep the world in contact and in motion in the way we have come to expect.

Security and Transport

Applications of technical ceramics in security and defence include bulletproof vests and infrared night vision devices. The high thermal insulation and wear-resistant properties of ceramics explain their use in jet engine turbine blades, disc brakes and bearing components. Contributing to safety and reliability, technical ceramics are found in a vast range of applications in rings and valve components, Combined Cycle Gas Turbine (CCGT) ceramic turbine blades, vacuum components, airbag sensors, catalytic converters, high-temperature fuel injection systems and other specialised markets.



Renewable Technologies

Many functions in renewable technologies require high-quality products that can only be manufactured with high-quality abrasives, refractories and technical ceramics. The production of the high-purity glass required for solar panels is one example, refractory products used for manufacturing silicon wafers (the semiconductor in crystalline silicon solar panels) is another. Ceramic-based products are also widely used in wind turbines and other solar panel components, such as anti-friction bearings, heat-sinks, fuel cells, tensiometers and insulation rings.

A SUSTAINABLE FUTURE

Further research into the use of nanoengineered ceramic materials to store energy, particularly from wind turbines and solar arrays, could provide the solution to the so-called 'energy bottleneck' that inhibits the widespread adoption of wind and solar power. New nano-ceramics would be key components in the next generation of capacitors that are smaller, lighter, longer-lasting and more efficient and could be applied to conventional energy storage as well as for intermittent sources such as wind and solar. Ceramics, one of the most ancient technologies in human history, could therefore be key to unlocking next-generation energy storage and enabling future generations to harness renewable technologies.

Storing energy at source is just one of many uses for ceramics in the low-carbon economy. Next-generation capacitors could also play a role in developing more efficient electric vehicles and other devices. Researchers are developing new high-tech ceramics for highly-efficient solid oxide fuel cells. Ceramics are also being used to develop new non-toxic coatings to prevent metal surfaces from rusting and to develop the next generation of water filters.

Call to Policymakers

The global economy is currently in transition with austerity measures being taken at home and abroad. And yet, with the right policy framework, we see the future European ceramic industry being an even more innovative and world-class industry with increasing employment, a strong supply chain and enhanced skills to meet current and emerging market needs.

In line with other sectors, we call on policymakers to create a **supportive regulatory framework** to keep manufacturing competitive in Europe and to help us make the European Union's objectives on **smart, sustainable growth** and competitiveness a reality.

Our industry is **world-leading** yet predominantly a **local** one, with significant employment in clusters and local supply chains. As a large number of ceramic companies are SMEs, this industry provides **sustainable employment** as well as **leadership in innovation**.

Ceramics are produced all over the EU yet there is an increasing threat from imports and **carbon and job leakage** to countries outside the EU.

Lifecycle

It takes energy to make and transport products from all sectors. Our main 'ask' to policymakers is that they take a **lifecycle** view of emissions and assess more than the carbon emitted in the production phase, particularly as the ceramic industry is so interconnected with the performance and energy efficiency of many other sectors.

As shown in this Roadmap, our technologies can even reduce overall emissions when considering the whole lifecycle, i.e. during the use phase and at end of life. As resources become scarcer, consumers need help to make more environmentally-responsible choices. Regulators can help move people away from '**throwaway**' choices and towards materials with a sound **lifecycle profile. Green public procurement** can also encourage more sustainable consumption patterns, for example by favouring energy-efficient materials.

Without a policy shift to measure emissions based on the whole lifecycle rather than during production only, there is a danger that legislation will misguidedly drive consumers to either ceramic materials made in less **environmentally-stringent** countries or to other less durable products with higher annualised emissions. This approach would be detrimental to both the European economy and global emissions.

Measuring resource efficiency requires appropriate **indicators**. The proposal in the Roadmap for a resource-efficient Europe does not take into account the lifecycle, availability of raw materials, durability of the product, end-of-life emissions or energy in the use phase. True resource efficiency can only be based on a lifecycle approach.

Trade

The European ceramic industry is affected by international **market access** issues and **trade barriers**. To tackle a wide range of trade and non-tariff barriers, we need to resort to all available trade policy instruments, both in a bilateral and multilateral context, including negotiations and enforcement procedures. **Strong action** must be taken against all unfair trade practices including counterfeiting, infringement of intellectual property rights, dumping and subsidies. In the context of the ongoing modernisation of the Trade Defence Instruments (TDI), it is essential that the EU preserve an effective regulatory framework on Trade Defence Instruments such as anti-dumping and anti-subsidy. Ceramics are made from a wide range of materials, from locally-sourced clay to natural or synthetic high-quality industrial minerals. As these industrial minerals are to a large extent imported from outside the EU, secure and fair **access to these raw materials** is vital. Eliminating **WTO infringements on procurement** and **reducing red tape** as much as possible are therefore prerequisites for a competitive ceramic industry in Europe.

Investment Cycles

Recognising that some of the best available and new technologies, e.g. for energy efficiency, have significantly longer paybacks than shareholders and banks will lend for, industry needs access to **affordable finance** - perhaps repaid from the resulting energy savings - for capital projects with longer payback periods.

The ceramic industry today predominantly uses natural gas. While some policymakers have advocated moving the industry away from gas to electric kilns once European electricity supplies are decarbonised, **this is not an economic solution** at present nor in the foreseeable future.

If the 2050 targets are to be achieved by making a large-scale move away from natural gas and onto biogas, syngas or other renewable energies, the ceramic industry needs to be assured of a **sustainable, uninterrupted** and **affordable supply** of these alternative fuels and proven technology through demonstrators. This is essential as efficient kilns must work continuously and cannot easily be switched off due to energy supply problems.

Our industry's experience with renewables, for example wind or waste transformation plants, has not been smooth across the board. **Permitting** processes in the Member States must support industry's shift to renewable energy installations if industry is to rely on a secure supply of alternative fuels.

Climate and Energy

For investment security, the ceramic industry needs a **consistent and predictable legal framework** across the EU's climate and energy policies. The implementation of current and future measures, such as the rules on new entrants and allowance retention, must not hinder new investments, plant improvements and growth.

The EU must continue to pursue a clear strategy towards an **international legally-binding climate agreement** with a **comparable burden** for industry based in the **major trading partners** which compete with the European ceramic industry, such as the BRICs, Egypt, Mexico, South-East Asian countries and the United Arab Emirates.

Equally, **international agreement** is needed to give equal consideration to industries mainly composed of **small emitters** like the ceramic industry. In the absence of a multilateral agreement, free allocation of allowances and national support schemes for indirect costs from electricity must apply to avoid **carbon and job leakage**. Other measures such as import taxes should be assessed.

Long-term climate policy will need a broader approach which also takes into account **consumed or imported emissions in products** in the EU to ensure that Europe is not simply decarbonising by deindustrialising.

Ambitious climate targets will require **breakthrough technologies**. Therefore, the target-setting policy must be accompanied by **financial support** to facilitate development and investment in low-carbon technologies. This could be partly funded by recycling existing energy taxes and CO_2 auctioning revenues.

Innovation

Meeting the EU's ambitious medium and long-term climate targets will require **breakthrough technologies** to come to market quickly to help reduce energy use and transition to low-carbon fuel sources, particularly given the lifecycle of ceramic installations, which on average is 30 to 40 years. Target-setting should be accompanied by financial support to facilitate the **transition**.

Developing these breakthrough technologies requires a supportive research and **innovation policy** framework. This Roadmap refers to some of the technologies we believe can make a difference today although the development of other, longer-term technologies is still essential.

Process industries, including ceramics, take raw materials and transform them into highly value-added products. Cerame-Unie is actively involved in the future SPIRE public-private partnership (PPP) dedicated to **innovation** in the process industries. SPIRE supports the process industries in their move to becoming more resource and energy-efficient in line with the EU's objectives and Roadmaps. For example, the SPIRE roadmap recommends a 20% reduction in non-renewable, primary raw material intensity and a 30% reduction in fossil fuel intensity from current levels by 2030.

Ceramic products contribute to the development of innovative solutions for sustainable buildings. In this context, ceramic building materials can play a crucial role in the energy-efficiency of buildings public-private partnership (E2B PPP). The ceramic industry counts on policymakers to make these PPPs a reality.

The creation of a business-friendly and innovation-conducive economic, regulatory and legal framework to effectively support the development of innovative products is a priority for our industry. We acknowledge Europe's objectives for a competitive, low-carbon economy and **Europe's leadership position** and ability to set the example globally. However, the sooner a level playing field can be established globally on emissions, the easier it will be for all European companies to compete globally and for real **climate abatement** to take place.

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 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

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

Intergovernmental Panel on Climate Change (IPCC) - A scientific intergovernmental body whose mission is to provide scientific assessments on climate change caused by human activity

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

SPIRE - Sustainable Process Industry through Resource and Energy Efficiency

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

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