THE ROLE OF CERAMICS IN THE CIRCULAR ECONOMY

CIRCLE ECONOMY

KNB
Vereniging Koninklijke Nederlandse Bouwkeramiek

CIRCLE ECONOMY

We are a global impact organisation with an international team of passionate experts based in Amsterdam. We empower businesses, cities and nations with practical and scalable solutions to put the circular economy into action.

Our vision is an economic system that ensures the planet and all people can thrive. To avoid climate breakdown, our goal is to double global circularity by 2032.

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The Dutch ceramics industry is constantly innovating to keep up with new trends and social challenges. KNB is the collective advocate of this proud industry.

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INTRODUCTION TO CIRCULAR CONSTRUCTION

A more circular construction industry
Sustainability—the ability to continuously meet our society's needs over time—is increasingly in the spotlight. In many respects, the construction sector in the Netherlands is still far from sustainable. For example, the built environment generates 40% of the country's waste and one-third of its CO2 emissions (including energy consumption during building use). The construction industry also plays a significant role in the Netherlands' current nitrogen crisis.

The circular economy principle
In a circular economy, products and materials are kept in use for as long as possible and reused at the highest quality. Negative impacts on the environment and nature are minimised by extracting fewer materials from ecosystems and producing less pollution and waste. Research shows that a combination of circular strategies—using regenerative materials, extending the life of products and using waste as a raw material—can go a long way in reducing CO2 emissions and achieving the goals Paris Agreement.*

The circular economy offers further benefits by reducing pollution, keeping ecosystems intact or even restoring them, and limiting the use of finite resources. In this way, the circular economy is an important tool for achieving sustainability.

We live in a linear economy
As of 2022, the Dutch built environment is only 9% circular.** This means that the vast majority of materials used in the construction sector come from virgin resources and raw materials. What's more, half of all resources used in the Netherlands are used within the built environment. A transition to a circular construction sector is therefore very urgent.

* Circularity Gap Report 2021, https://www.circularity-gap.world/2021

** Circularity Gap Report for the Built Environment in the Netherlands, 2022, https://www.circularity-gap.world/sectors

Definition of circular construction:

'Circular construction means developing, using and reusing buildings, areas and infrastructure, without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems. Building in a way that is economically responsible and contributes to the well-being of people and animals. Today and into the future.'

Transitie-agenda Circulair Bouwen (2018)

Need for change in construction

By 2050, one in seven people worldwide will live in a city, according to a United Nations projection.* This means that the environmental challenges of construction in urban areas will continue to grow in the coming decades. With this in mind, the negative impact of virgin material use must be reduced—from the use of raw materials themselves to the emissions of greenhouse gases, particulate matter and nitrogen. Laws and regulations from Brussels and The Hague are becoming increasingly stringent. In addition to reducing material use, current policy also focuses on limiting the number of transport movements, reducing noise pollution during construction and shortening construction times. To make progress in all these areas, the construction industry will have to make fundamental changes that future-proof the sector.

Ceramics: a modest impact, an essential role

The number one material used in new Dutch construction is concrete—making up nearly 90% of the construction sector's material consumption. Compared to this, other materials are used in much smaller quantities, such as sand (4%), ceramics (5%) and steel (4%).** While ceramics comprise a modest percentage in overall building materials, they do play an important role in Dutch construction. This is largely due to important functional properties such as weather resistance, low-level maintenance and long lifespan. Ceramics also have a unique design quality and cultural-historical value.

Ceramics: versatile in application

Ceramics have a wide range of applications, from roof tiles to stone strips, bricks, baked pavers and ceramic tiles. Ceramics can be used both indoors and outdoors, in dry and wet conditions. Ceramic products define the architecture and experience of structures, pavements and neighborhoods. Moreover, they protect a structure and its users from the elements. Finally, ceramics are low-maintenance and work well with low-temperature heating from heat pumps. This versatility of applications ensures that ceramics have and will continue to play a fundamental role in construction.***

* United Nations, World Urbanisation Prospects, The 2018 revision, population.un.org/wup/Publications/Files/WUP2018-Report.pdf

** Circularity Gap Report for the Built Environment in the Netherlands, 2022, https://www.circularity-gap.world/sectors

*** CerameUnie (2021), Ceramic Roadmap to 2050, https://www.ceramicroadmap2050.eu/flip-book/

There are six design strategies* for circular construction, from a focus on preventing unnecessary material use to future-proofing a building. Ceramics can contribute significantly to architects' and clients' goals for five of the six strategies. Here's how:

PREVENTION

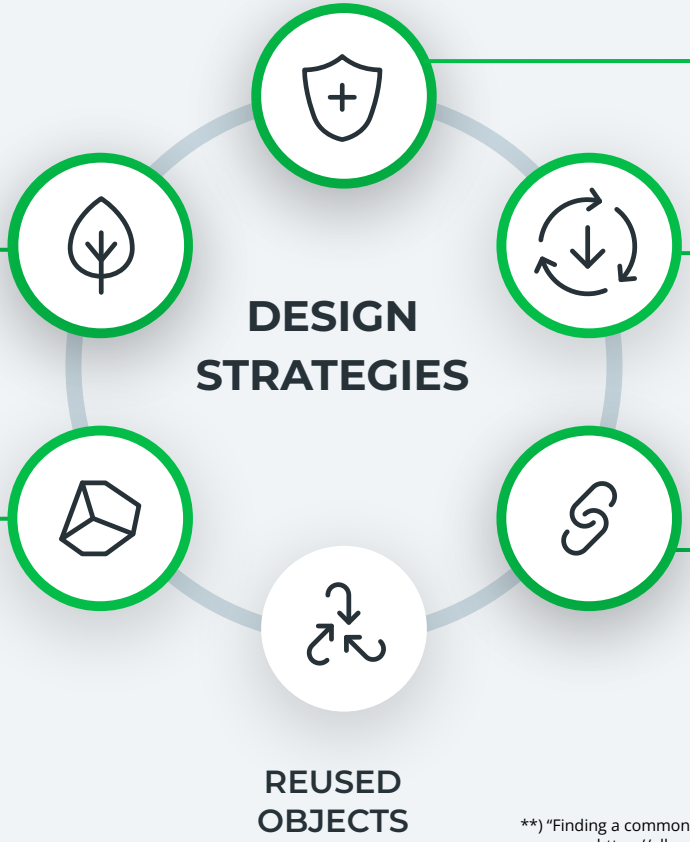
Manufacturers today offer narrower bricks and brick slips that require fewer materials and less energy during the manufacturing process.

RENEWABLE RAW MATERIALS

Ceramics are renewable due to the constant supply of clay from major rivers.**

LIFE CYCLE IMPACT REDUCTION

Ceramic products often have a lower life cycle impact than other products for facades, roofs and paving.



SECONDARY RAW MATERIALS

Detachable ceramic products—such as baked clinker bricks, roof tiles and dry stacked bricks—can be reused time and time again. Of all Amsterdam clinkers, for example, as much as 80% are reused.

FUTURE-PROOFING

Ceramics have a long lifespan, require low maintenance and protect against water and weather affects so that buildings last longer.

*) Leidraad Circulair ontwerpen, Platform CB'23, July 2021
**) "Finding a common language — the circular economy glossary", Ellen McArthur Foundation, https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/glossary

The sustainable properties of ceramics

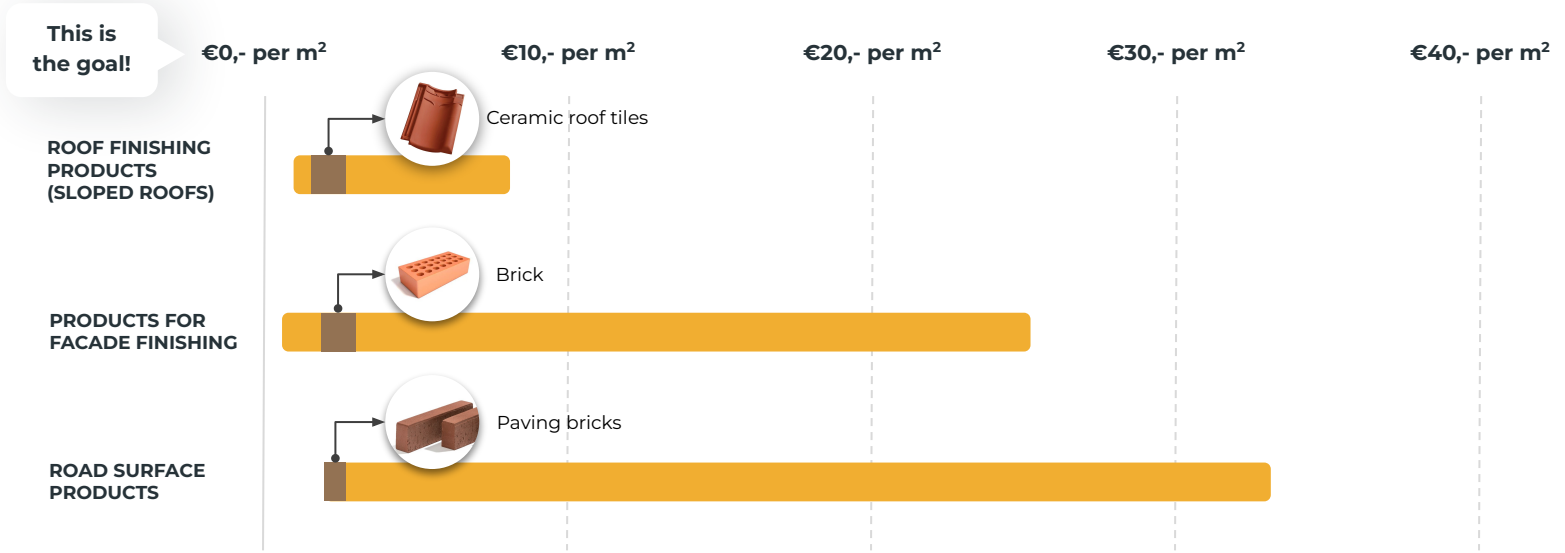
The environmental impact of ceramic products has already been reduced over the years through innovation within the industry. For example, more efficient firing processes and optimised kiln designs have significantly reduced energy consumption and greenhouse gas emissions over the past 20 years. In addition, the extraction of river clay in the Dutch floodplains is an essential part of water management. River clay is deposited annually and naturally accumulates across the Netherlands. It can, therefore, be considered renewable as long as the extraction doesn't outstrip the supply. Clay extraction also plays a role in the creation of new (cultivated) land. Finally, as a local product with a long lifespan and low maintenance requirements, ceramics also have valuable properties that not only make the material itself more sustainable than most alternatives, but promote the sustainability of a building as a whole.

Further improvement needed

Ceramic products are still a significant source of waste and their production creates greenhouse gas and nitrogen emissions. Further innovation is also needed, with not only incremental innovations but breakthrough techniques playing an important role. Here, innovations in production techniques, product formulas, as well as new partnerships and business models can play an important role in boosting the sector. In the following slides we will therefore describe in more detail which innovations are needed and where in the chain they should be applied.

The chart below shows the relative environmental costs of ceramic products compared to commonly used alternatives. The environmental costs for roof finishing, facade finishing and road paving are calculated in costs per square metre and give an indication of the costs of pollution, climate change, and other environmental effects based on Environmental Cost Indicators (MKI) data from the National Materials Database (NMD) that have been calculated using life cycle assessment (LCA). The environmental costs of ceramic products tend to be lower than many of the alternatives available on the market.

Environmental costs of ceramic products compared to alternatives



Graph based on data provided by KNB and extracted from GPR material and the NIBE environmental classification, October 2022

CURRENT CHALLENGES FOR THE CERAMIC SECTOR

CURRENT CHALLENGES

Dependence on fossil fuels

Ceramic firing and drying processes still often use large amounts of fossil fuels: the ceramic sector was responsible for 517 kilo tonnes of CO_2 emissions in 2019. The challenge remains to produce building ceramics with less and less energy, and to replace fossil fuels with energy from renewable sources.

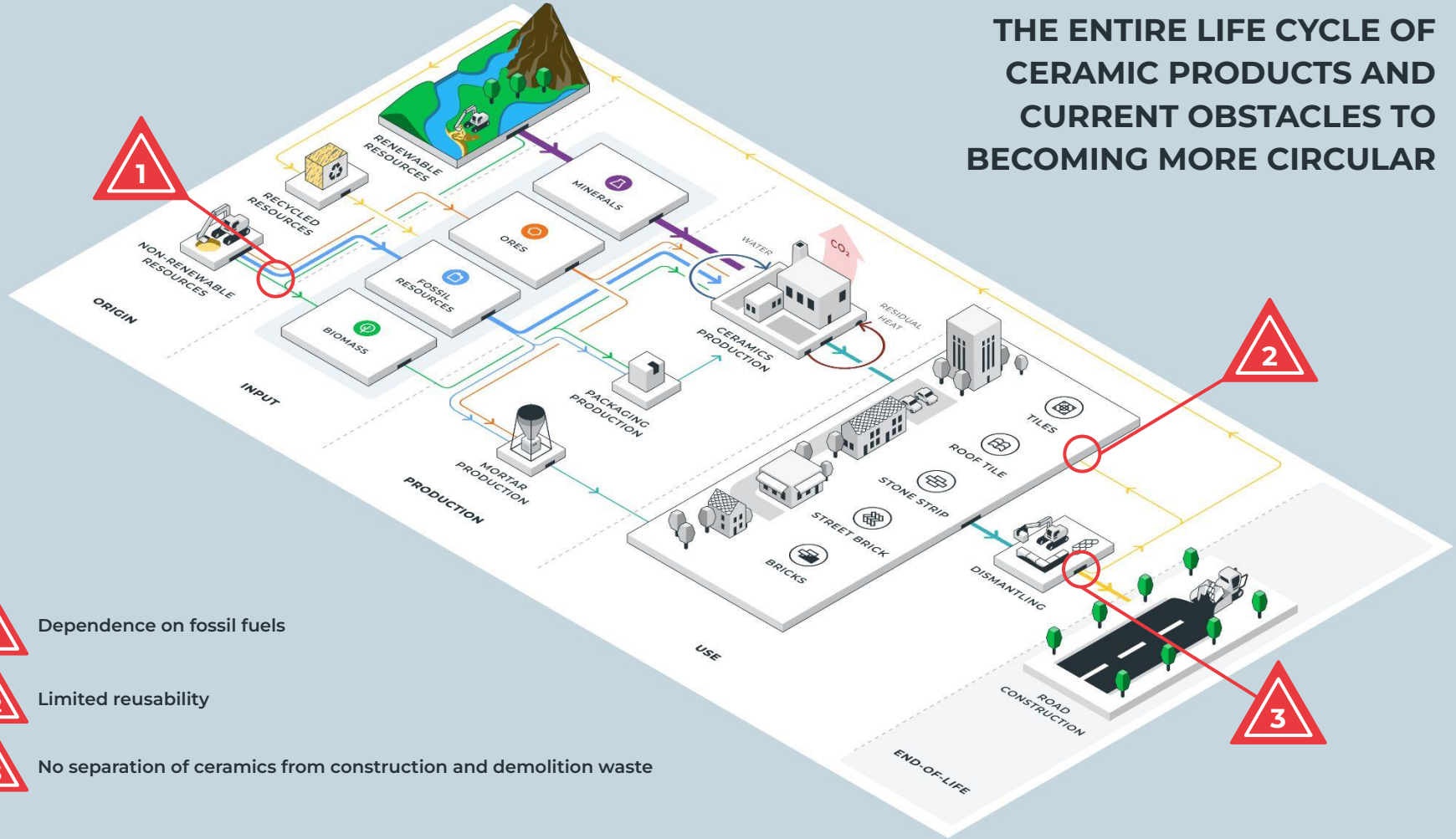
Limited reusability

Ceramic products are often not reusable after demolition and renovation. This is because they are often bonded to each other or a foundation and detaching them is impossible. As a result, it can be difficult to reuse or recycle the products at a high grade when they each their end-of-life. Low-grade application in road foundations or as granulate in the production of new building ceramics is already taking place. Meanwhile, masonry brick, tiles and stone slips are often not yet used in a detachable manner. For roof tiles and paving, much is already possible. The challenge is to increase the overall percentage of reusable ceramic materials and products, for example by using dry stack bricks.

No separation of ceramics from construction and demolition waste

As long as buildings are demolished after use without attention to the recovery of materials, the high-quality closure of cycles will remain limited. One solution is a transition to less destructive methods, such as precise building dismantling. In the current destructive system, the situation remains that much construction waste is recycled into granulate that serves as foundation material when building new roads, for example. By increasing the amount of detachable products, ceramics could be reused more easily and for high-quality purposes.

THE ENTIRE LIFE CYCLE OF CERAMIC PRODUCTS AND CURRENT OBSTACLES TO BECOMING MORE CIRCULAR



1. Dependence on fossil fuels
2. Limited reusability
3. No separation of ceramics from construction and demolition waste

Addressing **CURRENT CHALLENGES...**

1 Dependence on fossil fuels

The firing and drying processes in ceramic production use large amounts of fossil fuels.

2 Limited reusability

Due to bonding and the limited value of individual products, some ceramic products have limited reusability.

3 No separation of ceramics from construction and demolition waste

Many ceramics are not harvested during demolition and renovation, and are reused in low-grade applications.

...is important to these **DESIGN STRATEGIES...**

- **Prevention**
- **Renewable raw materials**
- **Life cycle impact reduction**

- **Secondary raw materials**
- **Future-proofing**
- **Life cycle impact reduction**

- **Secondary raw materials**
- **Future-proofing**
- **Life cycle impact reduction**

...and calls for action to these **CIRCULAR OPPORTUNITIES.**

1 Reduce fossil input

New technologies, including furnace technology and alternative fuels, enable the industry to transition to renewable energy.

2 Increase reusability

New product innovations make it easier to reuse ceramic products.

3 From product to service

Shifting from product sales to services, new joining techniques, and new laws and regulations may lead to the recovery of larger volumes of ceramics in demolition and renovation.

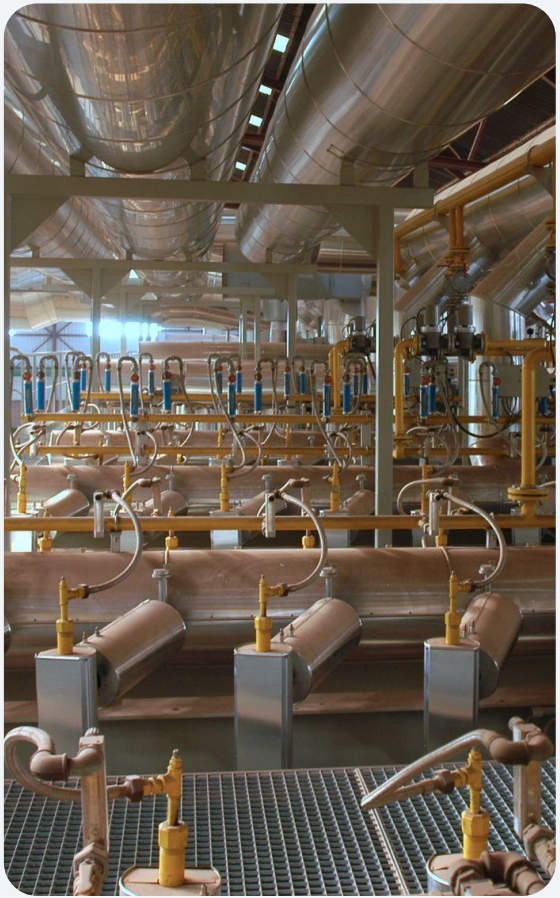
REDUCE FOSSIL INPUT

Rising energy prices, scarcity of fossil resources and climate change are all topics of increasing interest to society, politicians and construction companies. Likewise, reducing the use of fossil fuels and related emissions is a crucial and key issue for the future sustainability of the ceramic industry in the Netherlands.

Looking at current production processes, a focus on energy efficiency remains important. In particular, it would be beneficial to move away from the current energy-intensive production technique for **blue-black smelting**, whereby ceramic products lose their characteristic red color and become blue-black.

It will take more than incremental improvements in current technology to achieve significant reductions in CO2 emissions. One possible breakthrough technology is the use of sustainably produced **hydrogen** as a fuel for kilns in the ceramics industry, provided that higher nitrogen emissions from the associated kilns are addressed. In addition, current kilns for firing or drying ceramics can be replaced by alternatives that operate on **sustainably produced electricity**. For example, by using microwave technology for drying solid bricks.

Finally, **biogas** can be a potential solution at the corporate level. However, it does not seem realistic to deploy on a large scale within the ceramic industry, especially given the limited production capacity and the high demand for sustainable alternatives to natural gas. It may still serve as a transition fuel until better alternatives become available.



2 INCREASE REUSABILITY

Because many ceramic products are made from a single material—roof tiles, paving and dry stacking systems are already, to a large extent, easily reusable. Although this option is available, in practice it appears that reuse is still far from common. In addition, tiles, masonry bricks and stone slips are not yet applied in a detachable manner and therefore are not reusable in their entirety.

Many ceramic products are designed to be glued or bricked, but this is not always necessary. For example, in so-called 'dry stacking systems', bricks can be designed in such a way that no mortar is needed. Such **detachable systems** can make various ceramic product groups more circular. Especially for temporary or trend-sensitive construction, this design strategy provides a good business case.

An additional advantage of using such systems is that they offer new opportunities for employment because they require less training to assemble. In this way, the large-scale use of these systems can provide a partial solution to labor shortages and a higher social return on investment (SROI).

For products that are still glued or bricked (tiles, stone slips, bricks), it may pay to design the products for use in **precast elements that are modular and individually reusable.** Because these elements are larger in size than the individual strip or brick, they can be designed for disassembly and are higher quality than individual ceramic products. For these reasons, the business case for disassembly and reuse will be stronger.

FROM PRODUCT TO SERVICE

A challenging but potentially effective way to stimulate the reuse and recycling of ceramic products are **'Product-as-a-Service' (PaaS) business models**. In this model, the 'user' pays for the service of a well-functioning product, rather than the ownership of materials. In practice, this is particularly useful for larger and/or more complex building elements with a relatively short lifespan. Examples include a roof-as-a-service, a high-quality prefab element and The Circular Road.

For relatively simple construction products and/or products with a long lifespan, the 'product-as-a-service' model can be simplified to a **take-back guarantee, possibly combined with a residual value guarantee**, which technically does not leave ownership with the producer but in practice envisages the same outcome. In this case, the product is returned to the original producer and the customer gets part of their purchase price in return. The producer can then choose to reuse the product or recycle its materials.

To increase the effectiveness and profitability of PaaS businesses, **functional blending** for ceramic products can be a solution. A roof tile with integrated solar panels or stone strips integrated into a reusable precast element are important building elements for demolishers to collect separately for reuse. However, end-of-life needs to be considered when mixing functions: more complex products can lead to a more difficult and expensive recycling process.

Another valuable impact of PaaS models is the more **involved relationship with a customer**. Instead of a one-time transaction, a long-term customer relationship is now created in which the customer is unburdened and the producer can build a sustainable customer base. This also opens the way to **more services**, such as consulting on construction projects, a service for cleaning and sorting used ceramic products, or performance contracts.

THE NEED FOR MORE VALUE CHAIN COOPERATION

The transition to a circular economy requires a value chain approach in which several actors in the supply chain change their ways. This also applies to the ceramics industry. The following slide describes some of the actions needed in various links of the chain. In order for these actions to fit together, cooperation is necessary at three levels: at the standards level, the company level and the industry level.

Collaboration on standards
There is a growing number of sustainability measuring tools, standards and databases, such as MKI, MPG, NMD, EPD, and BREEAM. With advancing insight and growing sustainability ambitions, these are increasingly being tightened and updated. For the ceramics industry, it is important to be a pioneer and participate in the NEN, CB'23, and similar initiatives, standards committees and other initiatives related to measuring sustainability and circularity.

Cooperation between individual companies
The need for further collaboration is also growing at the corporate level. From jointly developing prefabricated panels with a carpentry factory to optimising the design for a housing development to inspecting the quality of reusable products for customers, the ceramics industry will increasingly need to partner with suppliers, construction companies and clients to achieve shared goals. This will require other suppliers to actively reach out to establish new collaborations.

Broad industry collaboration
The sustainability goals of the ceramics sector must be linked to current social issues and trends. They should consider, for example, countering the growing housing shortage, combatting nitrogen and CO2 emissions, contributing to livable cities, or minimising the nuisance caused by construction activities. This complex playing field requires a clear and coherent vision of where the sector should go.

An effective way to achieve this is for representatives from all the links in the broad Dutch ceramics chain and the government to join forces in a ceramics agreement, inspired by similar initiatives such as the Steel Construction Agreement, the Concrete Agreement and the various Green Deals. In such an agreement, chain-wide consensus can be laid down for the reduction of CO2 emissions, accelerating the circular economy, increasing construction capacity, using smart technology and much more. As a result, there will be more trust in mutual cooperation, investment risks will be reduced and innovation will be accelerated.

EVERYONE IS NEEDED FOR THE NEXT STEP

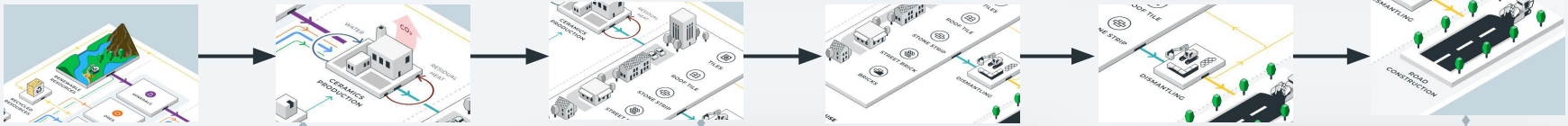
With an already rich history, their versatility and durability make it almost impossible to imagine a circular future without ceramic products. However, major steps are needed in the recovery of materials and the elimination of fossil fuels before the sector can rightly be called circular. The question we need to start asking each other is not ‘are ceramics circular?’ but ‘are we *making* ceramics circular’? More and more large-scale collaboration in the industry, in the supply chain and beyond provide an answer. Below are six examples where such collaboration is needed.

1. Investing in sustainable energy
The ceramic industry will have to invest in hydrogen or electric kilns to reduce dependence on fossil fuels. Government assistance is needed to invest in the necessary infrastructure.

3. More collaboration in the design phase
Contractors and suppliers, including the ceramics industry, must meet with developers and contractors in the early design phase to identify and incorporate appropriate sustainable and cost-effective solutions.

5. From demolition to harvest
To harness the circular potential of ceramics, demolition and renovation processes must be adapted to recover products more frequently and in better quality. For example, through automated sorting processes, more time and attention to dismantling, and digital marketplaces for reusable building materials.

EXTRACTION | PRODUCTION | BUILD | USE | DISMANTLE | REUSE



2. Investing in product innovations
The ceramics industry must continue to invest in product innovations in order to produce products that use less energy and materials, last a long time, are detachable, can be dismantled quickly, offer sufficient value when reused and are easy to recycle.

4. Manage clear ambitions
Measurement tools, like the Environmental Cost Indicator (MKI) and the Environmental Performance of Buildings (MPG), have proven to be effective in steering towards more environmentally friendly construction. The government should make more stringent MPG scores mandatory and allow these tools to also be applied to existing construction to accelerate the transition.

6. New foundation materials
When more building products, including ceramic products, are used in a high-quality manner, designers and developers will have to look for suppliers of alternative foundation materials.

COLOPHON

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