Position Paper

Hydrogen Europe Research

# The Role of Low-Carbon Hydrogen

## in Decarbonizing Glass and Ceramic Manufacturing in Europe


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# Abstract

The paper investigates the integration of hydrogen as a decarbonization strategy in the European glass and ceramics manufacturing sectors. The primary goal is to analyze the potential, current initiatives, and future opportunities for green H2 adoption, with a focus on reducing sector-specific carbon emissions and supporting the transition to net-zero by 2050. The methodology involves a review of pilot projects, and technological advancements across various sub-sectors, including glass, ceramics, bricks, sanitaryware, and cement, highlighting both successful industrial-scale demonstrations and ongoing feasibility studies. Key insights reveal that H2 can significantly mitigate CO2 emissions, particularly in energy-intensive processes where fossil fuels dominate. Notable pilot projects demonstrate the technical viability of H2 combustion in glass furnaces and ceramic kilns, with some achieving substantial emission reductions and maintaining product quality. However, the study identifies critical challenges: high capital and operational costs, limited H2 supply, the need for technological adaptation, and concerns regarding product quality and safety. The paper concludes that while H2 presents a promising pathway for decarbonization, its widespread adoption will require sustained innovation, policy support, and investment to overcome economic, technical, and regulatory barriers and to ensure the sector's alignment with Europe's carbon neutrality targets.

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# Introduction

Hydrogen, particularly when produced from renewable sources, is increasingly regarded as a sustainable and eco-friendly energy carrier. Its integration into industrial processes, especially in the manufacturing of glass and ceramics, is attracting significant attention due to escalating environmental concerns and the global drive towards net-zero emissions. In addition, adopting green H2 in industrial processes offers substantial image benefits for companies, particularly as consumer preferences evolve. By 2050, the primary buyers will be today's younger generation, who are developing a strong environmental consciousness and are likely to favour products with minimal environmental impact. Companies that can demonstrate a genuine commitment to sustainability by integrating green H2 will be able to distinguish their products as truly green, enhancing brand reputation and consumer trust. This differentiation is expected to translate into increased market share and customer loyalty, as eco-friendly credentials become a decisive purchasing factor. Another significant advantage for companies using H2 is reduced exposure to fluctuations in fuel prices, which are often driven by volatile international markets. By decreasing reliance on imported fossil fuels, businesses can achieve greater price stability and predictability in their operational costs. This resilience not only safeguards profit margins but also facilitates long-term strategic planning, making companies less vulnerable to geopolitical tensions and supply chain disruptions. Further advantages include compliance with tightening environmental regulations, access to green financing, and improved stakeholder relations. Early adoption of H2 technologies also positions companies as industry leaders, fostering innovation and opening new market opportunities as the global economy transitions towards decarbonisation.


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# Current State of Research

The European ceramics sector currently emits approximately 19 million tonnes of CO2 annually. While this represents a substantial reduction of over 45% since the industry's peak in 2000, it still accounts for about 1% of total European industrial emissions. The primary sources of these emissions include: the combustion of fuels for drying and heating, CO2 released from mineralogical changes in raw materials (e.g., calcination of CaCO3), indirect emissions from electricity generation (cogeneration), and emissions from internal and external logistics. In some highly productive areas, with unfavorable meteorological conditions, slow air exchange due to climatic conditions can lead to legal limits for pollutant emissions being exceeded, posing serious health risks. In response, the European ceramics industry has established ambitious targets to significantly reduce its emissions by 2050, with the ultimate goal of achieving carbon neutrality. The proposed strategy encompasses various approaches, including: reducing process-related emissions, driving innovation to improve manufacturing efficiency, implementing CO2 capture technologies (CCS/CCU), exploring additional carbon removal techniques, and, crucially, utilising green H2 as a fuel. A promising pathway for emission reduction involves using it and waste carbon dioxide from glass and ceramic production to produce synthetic fuels, such as methane. This approach allows many producers to maintain their existing technology, including highly sensitive and efficient thermal machines like spray-dryers and kilns, while significantly lowering net CO2 emissions by converting captured CO2 into methane through a methanation process with green H2 [1].

## 2.1 Hydrogen project examples

Green H2 has been identified as a key means of mitigating CO2 emissions in the energy-intensive glass and ceramic manufacturing industry, where over 70% of energy currently comes from fossil fuels like natural gas [2-3]. Numerous projects are demonstrating the application and potential of H2 across various sectors. The following tables present some examples of applications.

### 2.1.1 Glass production.

| Project name | Description |
|---|---|
| **H2Glass**<br>https://h2-glass.eu/ | H2GLASS is driven by 23 strong partners from 8 European countries representing research and industry institutions, major manufacturers from the glass industry. The objectives of the project are different.<br>– Develop the technology stack that will enable 100% H2 combustion in the glass industry.<br>– Validate H2GLASS technology through application in industrial context.<br>– Prove economic and environmental viability of H2GLASS solutions compared to fossil fuels.<br>– Develop IT architecture for automatic control and management and more efficient industrial processes.<br>– Raise public understanding on H2 technology as a solution for decarbonising industrial processes.<br>Transfer technology to other EU energy-intensive industries. |
| **SCHOTT**<br>https://www.schott.com/en-gb/news-and-media/media-releases/2024/schott-produces-optical-glass-with-100-percent-hydrogen | After successfully testing glass production with 100% H2 on a laboratory scale, the group Schott has completed the industrial-scale application. For three days, the glass expert melted optical glass in a furnace using the new technology for the first time. Schott reports successful trials of using 35% H2 for industrial-scale glass production. |
| **Pilkington**<br>https://www.pilkington.com/en-gb/uk/news-insights/latest/pilkington-uk-plans-to-scale-low-carbon-glass-production-under-pioneering-hydrogen-plans | Pilkington United Kingdom Limited, intends to use green H2 at its site and scale its production of low carbon glass from 2027, under pioneering new plans. The project would enable the company to eliminate 15,000 tonnes/y of carbon from its direct emissions. |
| **H2 project (H2) by Saverglss**<br>https://www.saverglass.com/en/csr/actions/hydrogen-project | Saverglass reported successful trials at its hybrid furnace. The project team carried out tests on H2 injection at three different rates: 10%, 20% and 30%. |
| **Hrastnik1860**<br>https://hrastnik1860.com/wp-content/uploads/5.12.23_Hydrogen-bottle-press-release.pdf | In 2023, it reached the significant milestone of using more than 60% of H2 for their combustion needs during glass bottle production. This has led to a reduction of over 30% in CO2 emissions. |
| **DIVINA**<br>https://www.spevetro.it/divina-project-research-on-hydrogen-natural-gas-mixed-combustion/?lang=en | Research on H2 – Natural Gas mixed combustion |
| **HyGlass**<br>https://www.energy4climate.nrw/en/topics/best-practice/hyglass | By replacing natural gas with H2 in the melting process, a reduction in CO2 emissions of around 3.3 million tonnes could be achieved across Germany as a whole. |
| **Ardagh Glass Packaging-Europe (AGP-Europe)**<br>https://www.ardaghgroup.com/2024/ardagh-pioneers-onsite-hydrogen-energy/ | Ardagh Glass Packaging-Europe announced that it is now producing green H2 for glass melting via an electrolyser at its facility in Limmared, Sweden. Since testing of the electrolyser began in October 2024, the furnace has successfully combusted 109,000m3 of H2 produced on site, saving 70 tonnes of CO2. |
| **Hynet**<br>https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1119899/phase_3_hynet_industrial_fuel_switching.pdf | Hydrogen Firing in a Glass Furnace |
| **COSiMa Saint-Gobain**<br>https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1119899/phase_3_hynet_industrial_fuel_switching.pdf | Saint-Gobain announced the launch of the COSiMa project, which aims to investigate the feasibility of using H2 for glass production. |

### 2.1.2 Ceramic Tile Production.

| Project name | Description |
|---|---|
| **H2 FACTORY®**<br>https://www.irisceramicagroup.com/en/media/iris-ceramica-group-and-edison-next-for-h2-factory-the-first-ceramics-plant-powered-by-green-hydrogen-produced-on-site/ | Iris Ceramica Group and Edison Next will develop a production facility that will run on green H2, produced on-site using a cutting-edge custom-designed system. Technical ceramic slabs (3.2 m x 1.6 m x 12 mm thick x sustainability) were produced by using a blend of H2. |
| **Revigrés**<br>https://ceramicworldweb.com/en/news/revigres-adopts-new-100-green-complete-production-line | This ceramic tile manufacturer will build a complete production line for 100% green porcelain tiles, consisting of a 7-level horizontal dryer, a TITANIUM®H2 oven using H2. |
| **SITI B&T**<br>https://gruppobt.com/en/hydrogen-kilns-within-three-years-siti-bt-research-looking-towards-the-energy-transition/ | Siti B&T manufactures a kiln for firing ceramic tiles that initiates a process of gradually replacing traditional methane with a H2-based gas blend. This innovation aims to further reduce the use of fossil fuels and atmospheric emissions. |
| **Sacmi**<br>https://sacmi.com/en-US/ceramics/news/19660/The-first-tile-fired-in-a-100-hydrogen-kiln-It-s-from-SACMI | Sacmi produces a 100% hydrogen kiln. |

### 2.1.3 Bricks and Roof Tiles Production.

| Project name | Description |
|---|---|
| **HyBrick™**<br>https://www.mbhplc.co.uk/sustainability/hybrick/ | Michelmersh has announced plans to conduct a feasibility study to replace natural gas with H2 in the brick-making process. The programme is part of the £1 billion Net Zero Innovation Portfolio (NZIP) which aims to provide funding for low-carbon technologies to decrease the costs of decarbonisation. |
| **Forterra**<br>https://www.forterra.co.uk/paving-the-highway-to-hydrogen/ | They have completed the first phase of H2 testing at the Measham brickworks in North West Leicestershire. They experimented with 20% H2 mixtures across the whole range of bricks. |

### 2.1.4 Sanitaryware Production.

| Project name | Description |
|---|---|
| **Lucideon** https://www.iom3.org/resource/ceramics-fired-solely-by-hydrogen.html | Lucideon UK claims it has completed 100% H2 firing of sanitaryware. The test took more than 13 hours at 1,200°C. |
| **SACMI-Riedhammer** https://www.sacmi.it/en-US/ceramics/news/16208/Tailor-made-versatility-and-sustainability-SACMI-RH-drives-the-evolution-of-sanitaryware-tunnel-kilns | SACMI-Riedhammer kiln is the first H2-ready solution on the market: the standard machine can run on a H2-gas mix containing up to 20%. |

### 2.1.5 Tableware Production.

| Project name | Description |
|---|---|
| **BHS tabletop AG** https://tablewareinternational.com/bhs-tabletop-ag-fires-porcelain-using-hydrogen-for-the-first-time/ | The company has succeeded in firing porcelain exclusively with hydrogen. |

### 2.1.6 Cement and Refractory.

| Project name | Description |
|---|---|
| **Heidelberg Cement Hanson UK** https://www.heidelbergmaterials.com/en/pr-01-10-2021 | The pilot test used a mix of 100% climate-neutral fuels including H2 for commercial-scale cement manufacture. The proportion of fuels in the cement kiln's main burner was gradually increased to a wholly net zero mix made up of tanker-delivered H2 as well as biomass components and glycerine, generated as by-products of other industries |
| **Cemex Ventures** https://www.h2-view.com/story/cemex-to-install-plasma-based-hydrogen-production-tech-at-uk-cement-plant/2117887.article/ | The H2 produced by HiiROC (thermal plasma electrolysis) is used as an alternative energy source to fuel clinker production processes. |
| **Tarmac** https://www.agg-net.com/news/uk-lime-kiln-in-world-first-net-zero-hydrogen-trial | High-quality lime has been manufactured in the UK using H2 as a fuel alternative to natural gas. The project builds on the company's wider long-term sustainability programme and corporate commitment to deliver net zero by 2050 and cut $CO_2$ by 45% per tonne of product by 2030. |

# 3

# Research Challenges

## i) Advantages and Drivers

The push for H2 stems from its potential as a sustainable and eco-friendly energy carrier, crucial for achieving net-zero emissions targets. Its integration is a core strategy for industries, such as the European ceramics sector, to reach carbon neutrality by 2050, significantly contributing to global decarbonisation efforts. Green H2 can substantially mitigate CO2 emissions in energy-intensive processes and offers a pathway to lower net CO2 emissions. The desire to reduce pollutant emissions and improve public health in high-production areas further drives its adoption. Economically, green H2 offers a competitive advantage by enabling the production of environmentally friendly products that appeal to an increasingly eco-conscious market. Furthermore, its development within Europe is seen as a way to drive GDP growth and prosperity, creating new industries and jobs.

## ii) Challenges and Barriers

Despite the promising outlook, the integration of H2 into industrial production processes faces several significant “challenges and barriers”.

### Economic and Infrastructure Hurdles

For H2 to offer environmental benefits, it must be produced from low-emission sources of climate-altering gases. However, the substantial capital investment and operational expenses required for production plants result in higher costs compared to traditional fuels. Building and storing a H2 production facility makes the overall production process more complex. Furthermore, current production capacity is insufficient to meet even a fraction of the potential demand from energy-intensive industries, highlighting the need for significant scaling up of infrastructure.

### Technical and Operational Complexities

Implementing H2 requires the recruitment of specialised personnel to operate facilities, as well as comprehensive training for all staff to ensure proficiency in responding to emergencies like leaks and explosions. Prior to its widespread implementation, a thorough examination of the impact of utilising H2 as a fuel on the final characteristics of products is imperative. It’s essential to maintain the quality and properties of goods currently produced, as directly replacing methane with H2 could compromise the remarkable energy efficiency and product quality achieved by highly sensitive thermal machines like spray-dryers and kilns. The development of all the necessary technologies for introducing H2 into various production processes is also crucial. While some projects demonstrate high technological maturity (TRL 7-9), others are in early stages of development (TRL 1-4), indicating varying levels of readiness across different applications. Current H2 production capacity is insufficient to meet even a fraction of the potential demand from energy-intensive industries. Prior to its implementation, a thorough examination of the impact of utilising H2 as a fuel on the final characteristics of products is imperative. [4-5]

**Social and Regulatory Obstacles**

The widespread adoption of H2 faces significant social and regulatory obstacles. Public concerns about its safety and the risks associated with its use are prevalent. Misconceptions about H2's flammability and storage can slow acceptance, making education and transparent communication essential. Additionally, the lack of harmonised international standards for production, transport, and usage creates uncertainty for businesses and investors, hindering global market development. Addressing these issues requires coordinated efforts between governments, industry, and communities to build trust and establish clear, universally accepted regulations.


4

# Timeline and Resources

The existing information does not permit defining specific timeframes for addressing all the challenges of H2 integration in the glass and ceramics industries. Nevertheless, the European ceramics industry has set ambitious targets to significantly reduce its emissions by 2050 and achieve carbon neutrality. The presence of many projects, some of which are at an advanced stage, suggests that a significant number of plants could be operational in the long term. Much depends on EU and industrial policies to promote the ecological transition. In order to achieve net-zero emissions by 2050, there needs to be sustained, incremental innovation across decarbonisation technologies. This trajectory requires a long-term commitment to development and implementation that is aligned with globally recognised climate goals. Decarbonisation depends on continuous, phased technological and infrastructural advancements. Initiatives must prioritise scalable solutions that evolve alongside policy frameworks and market readiness to ensure measurable progress towards mid-century targets. It remains complex to quantify the exact funding requirements for emerging technologies. Projects supported in some countries amount to €1.2 billion. This figure serves as a benchmark, not a definitive sum, reflecting the scale of the resources required to overcome technical and commercial barriers. Significant public and private investments are already accelerating low-carbon innovation. Crucially, public financing acts as a financial multiplier, reducing project risk and mobilising private capital on a large scale. This synergy must be expanded strategically to bridge funding gaps and drive widespread adoption.


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# Rationale for Advancing Research in This Area & Potential Applications

Green H2 offers a multifaceted solution for the ceramics and glass industries, addressing key sustainability issues, societal benefits, economic impacts and strategic goals.

### Sustainability and environmental benefits:

As a sustainable and eco-friendly energy carrier, it is essential for achieving net-zero emissions targets. Integrating it is a core strategy for the European ceramics industry to reach carbon neutrality by 2050, and it will make a significant contribution to global decarbonisation efforts. Green H2 can substantially mitigate $CO_2$ emissions in energy-intensive processes, providing a pathway to lower net emissions by converting waste carbon dioxide into synthetic fuels.

### Societal benefits

Reducing pollutant emissions is particularly important in areas with high production rates, where slow air exchange can cause legal limits for pollutants to be exceeded, leading to serious health consequences for residents. Cleaner air directly improves public health and quality of life. Furthermore, investing in H2 technologies can foster innovation and create new jobs in the research, development and manufacturing sectors.

### Economic impacts

Adopting green H2 provides a significant competitive advantage. It enables the production of environmentally friendly products that appeal to an increasingly eco-conscious consumer base. Ceramic products are also inherently energy-efficient in use (e.g. bricks, refractories and double/triple glazing). Certifying products made with green H2 could significantly enhance a brand's image, appealing particularly to wealthy, environmentally conscious customers who may be willing to pay more, opening up new premium market segments. Furthermore, developing H2 technologies in Europe will boost GDP and prosperity, creating new industries and strengthening the continent's competitive position.

## Alignment with strategic goals

The drive to integrate green $H_2$ aligns directly with ambitious global decarbonisation goals and the carbon neutrality targets set by major industries. This strategic alignment demonstrates a commitment to future-proofing the industry and meeting international climate obligations. It also enhances energy security by diversifying energy sources and reducing reliance on volatile fossil fuel markets.

## Potential Applications.

Hydrogen can be applied as a fuel directly or as a component in mixed fuels for various high-temperature industrial processes within glass and ceramic production:

Glass Production: H2 can be used in furnaces for melting primary ingredients and recycled glass at temperatures typically ranging from 1,500–1,700°C.

Ceramic and Concrete Production: It is suitable for firing in kilns across various ceramic sub-sectors, including:

| Ceramic | Firing temperature |
|---|---|
| Glass | 1500–1700°C |
| Tiles | 1050–1230°C |
| Bricks and roof tiles | 950–1100°C |
| Sanitaryware and tableware | 1000–1400°C |
| Cement clinker and ceramic refractories | 1450-1500°C |

Synthetic Fuel Production. Green H2 can be combined with waste carbon dioxide from glass and ceramic production to create synthetic fuels such as methane, methanol, or dimethyl ether. This innovative approach allows manufacturers to significantly reduce their carbon footprint without requiring major modifications to existing key equipment like spray-dryers and kilns [6-8].

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