IDRIC

Decarbonising UK Glass and Ceramics: Building an Evidence Base

Sampurna Roy and Keith MacLean

September 2026



Contents

Preface from IDRIC Director....3
Acknowledgements....4
Executive Summary....5
1. Introduction....8
2. Methodological Approach....10
3.Cross-Cutting Themes....11
3.1. Technical Pathways....11
3.2. The Economic Context....15
3.3. The Competition Context....20
3.4. Logistics and Practicalities....21
3.5. Policy and Regulation....22
3.6. Policy Recommendations from Stakeholders....24
4. Glass Sector Deep Dive....28
4.1. Sub-Sector Specific Technical Challenges....28
4.2. Fuel Combustion Emissions in Glass....31
4.3. Supply Chain: Raw Materials....33
4.4. Research and development for the Glass Sector....35
4.5. Glass Sector Policy Recommendations from Stakeholders....36
5. Ceramics Sector Deep Dive....38
5.1. Fuel Combustion Emissions....41
5.2. Supply Chains....44
5.3. Regulatory Issues for the Ceramics Sector....46
5.4. Research and Development for the Ceramics Sector....48
5.5. Ceramics Sector Policy Recommendations from Stakeholders....49
6. Conclusions and Further Research....51
Bibliography....53

Preface from IDRIC Director

Industrial decarbonisation is central to delivering the UK's net zero ambitions, strengthening economic resilience and maintaining internationally competitive manufacturing sectors.

Through its close collaboration with energy-intensive industries, IDRIC seeks to accelerate the deployment of low-carbon technologies by fostering innovation, facilitating knowledge exchange, and strengthening partnerships across industry, academia and government. This report contributes to that mission by examining the glass and ceramics sectors, which are critical to UK manufacturing and supply chains, but face significant decarbonisation challenges due to their reliance on complex, capital-intensive, high-temperature production processes.

Drawing on extensive engagement with Small and Medium Enterprises (SMEs) and large firms across the sectors, trade associations, academic experts and policymakers, the report provides an evidence-based assessment of the barriers, opportunities and policy interventions required to accelerate decarbonisation. It has been informed through extensive collaboration with industry across two workshops and several one-on-one conversations to ensure findings are grounded in real-world practice.

Both sectors have demonstrated strong commitment through established net zero roadmaps, including British Glass' Net Zero Strategy and Ceramics UK's decarbonisation roadmap, and investments in energy efficiency. However, progress is increasingly constrained by high industrial energy costs, infrastructure limitations and growing international competitive pressures.

The findings highlight important differences between sectors. While much of the glass industry has access to technologies approaching commercial deployment, the ceramics sector faces more fundamental technological and economic barriers, with fewer viable decarbonisation options currently available at scale. Across both sectors, stakeholders expressed concern that the UK risks carbon leakage, reduced industrial investment and loss of productive capacity unless the business environment becomes more competitive.

The report identifies several policy priorities: reducing industrial energy costs, providing long-term policy certainty, strengthening competitiveness with key international markets, and expanding targeted capital and operational support for low-carbon technology deployment. Stable and coordinated policy frameworks are essential to unlock private investment and enable firms to make long-term decisions with confidence.

By combining industry experience with techno-economic and policy analysis, this report provides practical evidence to inform government, industry and stakeholder decision-making. It sets out the conditions required to accelerate industrial decarbonisation while safeguarding competitiveness, productivity and high-value manufacturing in the UK.

We thank all contributors for their expertise and encourage readers to engage with the findings, share them widely, and help translate evidence into action to strengthen both decarbonisation and long-term industrial competitiveness.

Prof Mercedes Maroto-Valer OBE
IDRIC Champion and Director

Acknowledgements

We would like to thank a wide range of stakeholders from academia, industry and government who contributed to the IDRIC sector-specific workshops and interviews and engaged with us bilaterally.

This report is supported by EPSRC and DESNZ funding, award number: EP/Z53125X/1, through the UK Industrial Decarbonisation Research and Innovation Centre (IDRIC).

We are particularly grateful to the following individuals who generously contributed their time and expertise to review the draft of this document, we are grateful for their insights and constructive feedback:

British Glass

Ceramics UK

Department for Energy Security and Net Zero (DESNZ)

Encirc
Martin Doherty

Heatcatcher Ltd.
Darren Bryant

Ibstock Plc.
Luke Menzel

IDRIC
Mercedes Maroto-Valer

Parkinson-Spencer Refractories Ltd
Jafar Daji

Wienerberger
Keith Jackson

Many thanks to the IDRIC Team members who supported these engagements.

While this report has been informed by extensive stakeholder feedback, the content does not necessarily represent the views of all individual members and partner organisations of IDRIC. The responsibility for the content of this report, including for any errors, lies with the editorial team. Whilst every effort has been made to ensure the accuracy of the information within this report at time of publication, IDRIC does not warrant its accuracy or will assume liability for any foreseeable or unforeseeable use made of this report which liability is hereby excluded.

Please note that Section 5.3.2 has been amended following stakeholder feedback.

Executive Summary

Background

The UK's glass and ceramics sectors are key for the UK's foundational industrial base, providing vital materials in critical economic supply chains and supporting wider economic resilience. Both are amongst the UK's harder-to-abate sectors due to their inherent characteristics. The term 'harder-to-abate' refers to sectors that require relatively more development, intervention and time to decarbonise. This underpins the rationale behind the focus on these sectors as priority areas for this report. Glass and Ceramics sectors rely on high-temperature, continuous processes that are technically complex and capital-intensive.

Large parts of both sectors have already explored and made investments in energy efficiency measures and waste heat recovery. **Glass** has made considerable investments and progress in hybrid and electric furnaces. In **ceramics**, fuel switching remains technically challenging as electrification is feasible only for smaller production lines and most operations require flame-based firing to achieve product characteristics. Therefore, hydrogen is the primary fuel-switching option being considered in the **ceramics** sector, but key barriers remain in terms of a lack of hydrogen supply and cost.

Decarbonisation challenges in Glass and Ceramics

Glass

The **glass** sector, particularly container glass, has already deployed a range of commercially available fuel-switching technologies. Fully electric cold top vertical melting (CTVM) furnaces are at Technology Readiness Level (TRL) 9. Hybrid natural gas and electric furnaces are typically at TRL 7-9, varying by scale and both producing 200-300 tonnes per day. Although the glass sector has successfully trialled hydrogen[1], hybrid hydrogen-electric furnaces are at a low TRL, as most glass firms do not expect hydrogen to be available by their next kiln replacement. Cold end operations downstream such as inspection, handling, conveying and packaging are also now almost entirely electric. Increased use of cullet (recyclable glass that can be remelted) is also used to reduce emissions.

Challenges remain for **flat glass** electrification, due to a different energy profile and increased wear of furnace parts. Electrifying flat glass also requires longer melt times and a horizontal process, whereas electric CTVMs are vertical.

Glass wool production has significant barriers as the fiberising and curing processes do not have viable low-carbon solutions. The fiberising process is also highly proprietary as individual firms have processes which are protected by their own patents. This means there is a lack of collaboration and knowledge sharing between glass wool firms on decarbonising the fiberising process.

Circular economy for **glass** also remains a key challenge as significant volumes of cullet are currently shipped overseas instead of used domestically due to UK waste and recycling policy.

Ceramics

The **ceramics** sector faces more structural and techno-economic challenges. The sector is predominantly firing with natural gas at present and fuel switching alternatives, like hydrogen and electrification, bring issues and constraints to their potential applicability across the diverse industry due to technology readiness, economic viability, supply and infrastructure considerations.

Electric kilns for smaller production lines and batch operations are at TRL 9 as they have been commercially demonstrated and are viable whilst challenges remain for electrifying larger kilns due to flame

[1] Glass Futures, "Completion of First Trials Campaign Marks New Chapter in Glass Futures' Decarbonisation Mission," published February 26, 2026, https://www.glass-futures.org/news/completion-of-first-trials-campaign-marks-new-chapter-in-glass-futures-decarbonisation-mission/

characteristics and combustion chemistry being integral to product quality. Conversion of gas fired to electric kilns is expensive due to design changes and the need for a new control system. In fact, a key barrier to electrification for the ceramics sector is cost, not only the capital expense of new equipment and complex conversions, but also ongoing electricity costs, which are often significantly higher than natural gas. ydrogen firing for ceramics is currently at TRL 7 and is rapidly progressing towards TRL 8, building on the success of Ceramics UK's breakthrough project in which a custom pilot kiln using 100% hydrogen is now operating[2]. However, hydrogen also has different combustion, safety and emissions properties which need to be considered during kiln design and operation. Hydrogen use predominantly depends on access to hydrogen and the hydrogen supply chain.

Around 30% of the **ceramic** sector's emissions come from the inherent chemistry of raw materials which cannot be addressed through equipment change and currently have no technological solution that addresses the underlying feedstocks. Carbon Capture, Utilisation and Storage (CCUS) may be a way forward for the sector's large installations. However, it is important to note that key economic considerations may make this infeasible, given that small emitters (sites emitting less than 25,000 tonnes of carbon dioxide equivalent each UK Emissions Trading Scheme (ETS) year), ultra-small emitters (sites emitting 2,499 tonnes of CO2e or less per ETS year)[3] and dilute emitters (concentration of carbon dioxide is under 10%.)[4] make up around 90% of the sector. The distribution of sites, away from industrial clusters, will also impact potential uptake of low-carbon technologies.

The **ceramics** sector also faces further regulatory barriers as they do not currently qualify for energy cost support such as the Supercharger Scheme, Indirect Emissions Trading Scheme (ETS) and Carbon Price Support Compensation Scheme. There are many key factors preventing access to energy cost support for the sector, largely around the accuracy and representativeness of 'real-world' data used in eligibility assessments.

Cross-cutting Themes

Across both sectors, a key distinction between technical capability and commercial viability persists as the economics of decarbonisation, especially the capital and operating costs associated with new technologies, prevent deployment of low-carbon technologies, even when they are at high TRLs. This remains a key barrier for firms, particularly in the **ceramics** sector which can undermine their viability.

Assets, such as furnaces for the **glass** sector and kilns for the **ceramics** sectors, have lifecycles of 15-50 years. This means that once a certain technology is locked in, it becomes incredibly expensive to change this despite changing policy developments.

High and volatile energy costs, particularly UK industrial electricity costs, make electrification commercially impractical, while upgrade costs and long lead-in combined with uncertainty over electrical capacity deter investment. Hydrogen faces similar constraints, with no national infrastructure or clarity on future availability or pricing.

High biomethane prices as well as uncertainty over CCUS infrastructure make these alternative pathways difficult to invest in as well. No zero-rating in the UK ETS for biomethane, in contrast to a zero-rating in the EU also creates a competitive disadvantage for the UK.

Competition also remains a key barrier in both sectors which reduces the capital available to make capital-intensive decisions. Firms compete with cheaper imports, either because international producers benefit from stronger government support for decarbonisation, cheaper energy costs or little pressure to meet

[2] Ceramics UK, "Ceramics UK Reaches Key Milestone in Hydrogen Project," January 24, accessed July 31, 2026, https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project

[3] Energy Advice Hub. "UK ETS | Emissions Trading Scheme | Frequently Asked Questions | FAQs." Accessed September 11, 2026. https://energyadvicehub.org/the-uk-emissions-trading-scheme-frequently-asked-questions/.

[4] Anas Majdouli, "The Challenges of Capturing CO_2 from Low-Concentration Emissions," Atoco, accessed September 11, 2026, https://atoco.com/blogs/the-challenges-of-capturing-co%E2%82%82-from-low-concentration-emissions/.

decarbonisation targets. Firms operating on tight margins due to import competition have even less capacity to self-fund decarbonisation investment and need targeted CapEx and OpEx support. Competition from alternative materials is also increasing, such as in packaging for the glass sector where weight-based Producer Responsibility charges incentivise using lighter materials, despite their poorer long-term sustainability, and competition between materials used in the construction sector affecting both glass and ceramics.

In the EU glass sector, several funding mechanisms and opportunities are available for firms to undertake fuel-switching, making the UK less attractive for investment and placing the UK at a competitive disadvantage when competing with the rest of Europe.

What could be done to reduce barriers and encourage more decarbonisation?

Across **both sectors**, lowering energy costs was highlighted as the first priority for firms to be able to decarbonise. These must reach levels comparable with international competitors. Energy-intensive businesses rely on natural gas to fire their kilns, with energy costs representing a significant overhead. Any meaningful support scheme must therefore address natural gas consumption. Beyond targeted support schemes, government must also address the structural disparity in UK energy pricing. UK manufacturers face energy costs roughly twice the European average and around four times those of their US counterparts, thus a competitive disadvantage that cannot be ignored.

Levelling the playing field with competitors by providing long-term support in the form of targeted CapEx and OpEx for both sectors is also key to allow deployment of technologies, even those at high TRL levels. Firms highlighted that the UK ETS revenues could be hypothecated for this and could be instrumental to unlock investment. Output-based mechanisms such as Contracts for Benefits (CfBs) for carbon reduction could provide a strong incentive by rewarding verified emissions reduction by providing a guaranteed stream of revenue. Particularly in the absence of a significant and sustained reduction in electricity prices, OpEx-based support, a CfB mechanism and CapEx support is needed to give UK industry the best chance of decarbonising and thriving against international competition.

Firms would also benefit from expert-led site support as fuel switching options are explored and adopted, and clearer regulatory guidance, e.g. on NOx compliance. Reduced administrative burdens and support for SMEs are also key as streamlined, consistently defined regulatory frameworks would ease compliance pressures, ensuring decarbonisation support is accessible to SMEs. A clearer methodology for government support schemes would help firms continue to operate whilst deploying decarbonisation technologies.

Both sectors require a stable, aligned policy environment across government and regulators. Firms are being asked to make multi-million-pound investments in assets that last 15-50 years. For this, they need clear and long-term policy signals.

In **glass**, the key focus remains on the primary route to decarbonisation through electrification, supplemented by hydrogen or biomethane and available funding should be targeted to support these primary pathways. Furnace manufacturers have developed designs for the next generation of hybrid and electric furnaces and funding is required to de-risk deployment. Further research, development and demonstration, is needed for the fiberising and curing processes for glass wool, inserting higher electric input into furnaces for float glass, and alternative raw materials such as biomass ash to help to decrease emissions from melting.

In **ceramics**, gaps remain in larger-scale high-temperature kiln operations, process emissions, product adaptation, advanced burners, and digital twin development to de-risk investment. Other research areas include commercially viable CCUS for smaller-scale and dilute emission streams, and disruptive carbon capture technologies enabling continued gas use while recovering the 30% carbon emissions inherent in the materials. Across **both sectors**, stronger academic partnership is key to support targeted, coordinated research for industrial needs to reduce technical barriers.

1. Introduction

The **glass** and **ceramics** sectors are essential to the UK's foundation economy. They are key materials in critical supply chains and present some key challenges for decarbonisation.

The UK **glass** sector produces 3.5 million tonnes of glass melted annually, contributing £2.1 billion to the economy, directly employing 6,000 people and indirectly supporting a further 150,000[5].The sector emits 1.5 million tonnes of carbon emissions annually from sites covered by the UK ETS, predominantly due to high temperature melting and process emissions from raw materials. Compared to 65 million tonnes of carbon emissions in 2024[6], this makes up around 2.3% of total manufacturing.

Over the past three decades, the **glass** sector has delivered significant emissions reduction, invested in advanced melting and abatement technologies, and increased recycled content[7], as energy use per tonne has almost halved. British Glass reports emissions fell from 0.749 to 0.611 tonnes of carbon emissions per tonne of melted glass by 2018, and a further 0.074 tonnes of emissions per tonne in process emissions reduction is possible as the latest estimate.

The UK **ceramics** sector directly employs over 20,000 people and while no official estimate has been published for total jobs supported, the sector underpins many thousands of jobs both upstream and downstream including construction, hospitality advanced manufacturing, power generation etc.[8] The sector is both a foundation and advanced industry, emitting around 1.2 million tonnes of carbon emissions annually across the sector[9]. Taking the Office of National Statistics (ONS) figures from 2024, this accounts for around 1.8% of emissions in total manufacturing.

The sector underpins foundational materials in key supply chains. For example, refractories are key for enabling both glass and steel production. Failure to safeguard this capability risks repeating the trajectory of the UK chemicals industry, which now relies on imports for around 80% of its supply, a key risk that has been made especially clear in light of recent geopolitical instability, including the conflicts in the Middle East and Ukraine. Without targeted support, the UK risks deindustrialisation that merely shifts production, and the associated carbon emissions, elsewhere, rather than genuinely reducing them, linked to the idea of "decarbonisation through deindustrialisation," an outcome the UK should actively seek to avoid.

The **ceramics** sector is highly diverse, geographically dispersed and dominated by SMEs with around three-quarters of firms operating single production sites. Emissions stem from process emissions during firing and fossil-fuel combustion, reflecting the sector's 80-plus year reliance on natural-gas kilns.

The scale of the decarbonisation challenge differs between the sectors:

Glass is comparatively closer to viable decarbonisation, and policy priorities therefore focus on deploying already viable technologies. With the right policy framework, the glass sector can decarbonise rapidly, but investment confidence depends on predictable, affordable energy prices, infrastructure development, and protection against international competition.

Ceramics faces a larger, structural challenge as large-scale processes lack like-for-like low-carbon alternatives, and most firms do not qualify for key government energy support schemes, raising the cost

[5] Sheikh, A.Y., Barker, B., Markkanen, S. and Devlin, A. (2023). "Glass sector deep dive: How could demand drive low carbon innovation in the glass industry." Cambridge: Cambridge Institute for Sustainability Leadership (CISL).

[6] Office for National Statistics,"Greenhouse Gas Emissions, UK: Provisional Estimates, 2024," statistical bulletin, released October 24, 2025, accessed September 23, 2026, https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/greenhousegasintensityprovisionalestimatesuk/latest.

[7] British Glass "Glass Sector Net Zero Strategy 2050." (2024) https://www.britglass.org.uk/sites/default/files/British%20Glass%20-%20Net%20Zero%20Strategy.pdf.

[8] Ceramics UK, Decarbonising UK Ceramic Manufacturing Roadmap: Interactive PDF (Stoke-on-Trent: Ceramics UK, 2024),https://static1.squarespace.com/static/6566f758dd1a4c385d6b7a86/t/65b8d0ce61458d1b000a5963/1706610905794/Roadmap+Interactive+PDF.pdf.)

[9] Reaney, I.M., Jouhara, H., Reece, M.J. et al. Sustainability and decarbonisation in the ceramics sector through resource and energy efficiency. J. Mater. Res. 41, 2088–2107 (2026). https://doi.org/10.1557/s43578-026-01920-8

differential for electrification. On May 21st 2026, the UK Business Secretary announced a £120 million funding package for the **ceramics** sector to invest in energy efficiency, decarbonisation and long-term competitiveness. This funding marks a step in the right direction in terms of government support which aims to support the strategically key sector. Discussions are yet to take place between government and industry on the detailed design and eligibility of the scheme.

This report aims to strengthen the evidence base for **ceramics** and **glass** decarbonisation by updating and building on the decarbonisation plans and pathways for each sector by drawing on existing IDRIC networks and the wider research community. The report identifies shared challenges, policy priorities as well as unique techno-economic challenges and Research and Development (R&D) needs for each sector. The report also highlights potential drivers and policy opportunities that could unlock further emissions reduction and investment.

This report is stakeholder-led and formed through extensive engagement with industry to capture real-world evidence and practice. It combines an initial literature review of academic, government, industry and trade-union sources, including the British Glass Net Zero Strategy and Ceramics UK Decarbonisation Roadmap, with two sector-specific workshops and a second round of one-to-one engagement. Follow-up individual discussions then gathered commercially sensitive, site-specific and technical detail to build a complete, representative picture across sub-sectors, firm sizes, product types and geographies.

2. Methodological Approach

This report was developed combining an initial collection of existing literature, two distinct rounds of engagement, one sector-specific workshop for each sector, and one round of one-on-one engagement with firms across sectors. This report is stakeholder-led and has been developed through extensive engagement with firms across the glass and ceramics sectors. It therefore reflects the views of participating firms in industry. The methodology was designed to gather techno-economic evidence, identify priorities whilst building sub-sector level detail for a whole-picture view of the diverse sectors.

An **initial literature and data collection** exercise of existing evidence was conducted, including academic articles, government reports, industry publications and previous trade union reports, e.g. the British Glass Net Zero Strategy[10] and the Ceramics UK Roadmap[11]. Much of the industry evidence collected is consistent with this literature. This report will highlight where significant differences emerged between published literature and industry insights from stakeholder engagement.

Two **sector-specific workshops** were held, one for the glass sector and one for the ceramics sector, with participation from manufacturing firms, trade associations and select academics across a range of sub-sectors. Workshops identified shared challenges across each sector, policy priorities and areas where sectors and sub-sectors diverged, highlighting where further detail was required. The workshops focused on technical barriers to decarbonisation, supply chain, market dynamics, regulatory and permitting issues and research and development needs for each sector.

The opportunity was provided for organisations to follow up and share any additional information after the workshop. A second round of engagement involved **individual discussions** with a number of firms, trade associations and expert academics to address key concerns, and build on the workshops. This engagement allowed participants to focus on issues most relevant to their operations and provided the technical detail needed to develop a complete and wide picture of each sector. Firms were able to share commercially sensitive information, operational detail and technical constraints privately that could not be discussed in a group. This included site-specific processes, location implications and unique technical considerations.

To ensure the analysis reflected the full diversity of each sector, the engagement process captured challenges and needs across sub-sectors, firm sizes, product types and geographical location and contexts. This allowed the research to be representative and distinguish between issues that are sector-wide and those specific to production routes, locations or business models.

[10] British Glass “Glass Sector Net Zero Strategy 2050.” (2024) https://www.britglass.org.uk/sites/default/files/British%20Glass%20-%20Net%20Zero%20Strategy.pdf.

[11] Ceramics UK, Decarbonising UK Ceramic Manufacturing Roadmap: Interactive PDF (Stoke-on-Trent: Ceramics UK, 2024),https://static1.squarespace.com/static/6566f758dd1a4c385d6b7a86/t/65b8d0ce61458d1b000a5963/1706610905794/Roadmap+Interactive+PDF.pdf.)

3. Cross-Cutting Themes

3.1 Technical Pathways

3.1.1 Energy Efficiency and Waste Heat Recovery

Energy efficiency and waste heat recovery are some of the most immediate and lower-risk decarbonisation opportunities available, relying on commercially proven technologies that can often be deployed without major process redesign. This makes them well-suited to near-term emissions reduction, while infrastructure, cost and availability of long-term pathways such as hydrogen expand.

Energy efficiency and waste heat recovery may offer significant near-term potential for the **ceramics** sector, such as in re-circulation in the drying processes and batch kilns where large volumes of heat are currently lost. Waste heat should be recognised as a resource in its own right that is freely generated as a by-product of existing operations. Rather than being lost to the atmosphere, it can be captured, redirected, or stored and applied across a range of processes, particularly in **ceramics**, such as drying, kiln preheating, space heating, and hot water provision. In a manufacturing environment, the potential to offset primary energy consumption through intelligent heat recovery is therefore considerable.

Realising this potential requires government support, both in terms of funding and access to technical expertise. However, it is important to note that when processes transition to electricity, the volume of recoverable waste heat decreases, limiting future supply and potential. If the waste heat is already being recovered and used elsewhere in the manufacturing process, this may be a key factor for firms to consider when transitioning to electrification.

3.1.2 Electrification

Electrification often requires fundamental changes to processes, equipment and site operations. This is even more pronounced in cases where a flame is essential to achieving key product characteristics.

This is particularly true for **ceramics** where electrification is one of the more challenging pathways (particularly for larger sites). Electrifying kilns (the largest emissions source for ceramics) is often incredibly difficult due to flame characteristics directly impacting material transformation. Electrifying large scale processes and kilns would often require far more power than local grids would be able to supply at present. Larger sites would also require significant changes to processes and operations, such as full kiln replacement. Opportunities for electrification in **ceramics** are in drying and some low-temperature processes. Smaller electrified kilns are used for smaller production lines, although this may come with efficiency losses.

In contrast, electric and hybrid furnaces are currently commercially available for the **glass** sector and are being deployed internationally. Electrification is being seen in the form of Cold Top Vertical Melting (CTVMs) for container glass sector, as well as electric-gas hybrid furnaces in flat glass. These technologies are viable and the challenge currently remains in deployment. No full electric furnace currently exists for flat glass as flat glass production needs to happen horizontally, and therefore CTVMs cannot be used.

3.1.3 Fuel Switch to Hydrogen

Fuel switching to hydrogen is the primary long-term alternative to natural gas viable for **ceramics**, particularly larger scale sites and production lines, given that it is a similar fuel type with similar combustion and operational characteristics as natural gas through a uniform flame-based heat source.

For **glass**, hydrogen is seen in a hybrid approach for float glass production which cannot be fully electrified. It is also a complementary pathway for container glass.

Hydrogen blending offers an introductory step, although its impact on emissions would be limited. For example, a 20% hydrogen blend by volume due to its lower energy density, would actually only deliver a 7% reduction in carbon emissions[12].

Across **both the ceramics** and **glass** sectors, individual company trials are taking place as well as trials through Ceramics UK and Glass Futures. Ceramics UK has successfully completed phase 1 of its hydrogen project using a custom kiln to research the use of hydrogen for ceramic production and the kiln is now operating using 100% hydrogen with phase 2 ongoing[13]. Similarly, Glass Futures has successfully completed their trial campaign on biofuels, electric melting, commissioning a new hydrogen fuel delivery system on the pilot line, enabling successful firing of hydrogen and natural-gas blends of up to 100% hydrogen[14].

Conversion costs, including both the kiln and site modification are likely to be significantly lower than electrification, especially as it can be delivered through the existing gas distribution networks and infrastructure once the old iron mains have been replaced by modern polyethylene materials. Although this replacement programme of the network is already over 75% complete and due to reach 100% in the early 2030s[15], delays could mean that a mains-based hydrogen supply may take decades to be a realistic option for most sites and could set up a very long delay in taking up other decarbonisation measures. It is worth noting that even the old iron mains networks carried town gas throughout the nineteenth and twentieth centuries until it was progressively replaced by natural gas during the 1970s. Town gas contained up to 50% hydrogen by volume. Hydrogen transport through gas networks is not a new or unknown procedure.

There are also challenges around hydrogen infrastructure as the transmission network may require significant replacement due to the risk of potential embrittlement with the higher pressures and materials involved. In some cases, a duplicate network may be needed in the transition to supply any users unable to process a blended supply. Mains-based hydrogen supply is likely to be delayed and industry is wary of relying on a hydrogen supply when considering fuel-switching options.

In addition, hydrogen availability is a major challenge for dispersed sites away from industrial clusters. This represents a key trade off with fuel-switching to hydrogen as although retrofit is more convenient when firms have the hydrogen supply (particularly for the **ceramics** sector if building a new electric kiln is not possible), accessing hydrogen supply remain challenging.

Hydrogen is less simple to deploy than biomethane as even a limited 20% hydrogen blend carries firing-sensitivity risk, so the practical emissions benefit may be lower still once quality-driven blend limits are applied in trials. Key technical challenges remain as the hydrogen flame is almost invisible, making it difficult for kiln operators to monitor the length and shape of the flame as well as heat distribution. There is also less radiative heating along with a higher flame speed and greater risk of flashback, Hydrogen combustion produces water vapour which can impact product quality. It also has a wider flammability range and lower ignition energy than natural gas and diffuses faster, presenting key impacts on safety and the need for ventilation and detectors. These factors introduce complexities in burner design, flame stability, furnace sealing and safety issues, and mean hydrogen conversion is not simply a fuel swap, but it often requires kiln-specific engineering work. This is a reason why generic "fuel-switching cost" estimates likely underestimate the true cost for **ceramics** manufacturers.

[12]Institution of Gas Engineers and Managers (IGEM) "To Unlock the Potential of Hydrogen, We Need to Embrace Blending at Transmission Level," (Brown: IGE, 2025), https://www.igem.org.uk/resource/to-unlock-the-potential-of-hydrogen-we-need-to-embrace-blending-at-transmission-level.html.

[13] Ceramics UK, "Ceramics UK Reaches Key Milestone in Hydrogen Project," accessed June 29, 2026, https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project.

[14] Glass Futures, "Completion of First Trials Campaign Marks New Chapter in Glass Futures' Decarbonisation Mission," accessed June 29, 2026, https://www.glass-futures.org/news/completion-of-first-trials-campaign-marks-new-chapter-in-glass-futures-decarbonisation-mission/.

[15] Institution of Gas Engineers and Managers (IGEM), "Investing in Mains Replacement Is Key to Meeting Our Safety and Environmental Goals: Here's Why" (Kegworth: IGEM, 2025), https://www.igem.org.uk/resource/investing-in-mains-replacement-is-key-to-meeting-our-safety-and-environmental-goals-here-s-why.html.

3.1.3.1 NOx Emissions

While decarbonisation discussions focus heavily on carbon emissions, NOx emissions represent a critical, often overlooked technical challenge which naturally arises when fuels are burnt in air at temperatures above around 1300°C. This is already an issue with natural gas, but hydrogen combustion can generate higher flame temperatures and further increase thermal NOx productions, potentially above current permitted levels. A kiln may reduce carbon emissions through hydrogen use whilst simultaneously increasing emissions of a pollutant which can impact on local air-quality as well as being an indirect greenhouse gas. Research conducted by some firms suggest that an increase in NOx from hydrogen may not result in a net greenhouse gas impact but will increase air quality issues.

NOx increases might require investment in additional abatement equipment and potentially affect compliance with existing environmental planning limits. Firms expressed concern that environmental permitting frameworks and Best Available Technology/Techniques (BAT) standards are not yet aligned with hydrogen firing. Current NOx limits are based on natural gas combustion and do not account for the different combustion chemistry of hydrogen. As a result, companies risk non-compliance if NOx emissions rise following conversion, even if overall greenhouse gas emissions fall. For example, for the **glass** sector, the current concentration limits would have to change to kilogram per tonne of glass melted limits. New limits would need to be determined for this new technique.

Burner suppliers are developing low-NOx hydrogen burner designs to manage this:

- In the **glass** sector, only three flat glass furnaces and a few container furnaces currently have De-NOx systems with a large proportion of container glass sites using bag filters, meaning that this abatement technique is not viable. Although selective catalytic systems (SCS) exist, this carries additional operating costs and could increase ammonia dosing, depending on the size of the catalyst. If the catalyst reaches its limits, this could result in ammonia slip and exceed ammonia limits, especially as the catalyst ages and becomes less efficient.
- For most **ceramics** sites, NOx abatement is currently not required and their complex gas-flow patterns, require careful assessment. Although some **ceramics** sites operate at temperatures less than 1100°C which reduces thermal NOx formation, hydrogen flames can still generate flame-driven NOx, making the overall impact both product- and kiln -specific. There are, however much higher firing temperatures used in the sector and requirements for NOx abatement are very much site-specific in nature to meet any regulatory requirements.

3.1.4 Fuel Switch to Biofuels

Biofuels are renewable energy sources produced from organic materials (feedstock) such as food scraps and animal waste. Biofuels exist in three vectors: solid (firewoods, wood chips and charcoal); liquids (bioethanol and biodiesel); and gaseous (biogas and syngas)[16]

Liquid biofuels have performed well across multiple industrial trials in the **glass** sector with successful operation on both float and container lines. Liquid biofuels can deliver 90-95% carbon reductions and represent an immediate practical decarbonisation option for existing furnaces. Many sites already maintain liquid-fuel backup systems, enabling relatively simple upgrades to biofuel use. Challenges for the use of biofuels include the price, being more expensive than natural gas, as well as the grade of biofuel. Biofuels vary in quality, with some containing contaminants. This variation influences the security of supply as well as cost.

[16]Jord International, "Biofuels Basics: Exploring Solid, Liquid, and Gaseous Biofuels," Jord International, accessed September 16, 2026, https://www.jord.one/blogs/biofuels-basics-exploring-solid-liquid-and-gaseous-biofuels.

3.1.4.1 Fuel Switch to Biomethane

Biomethane is upgraded biogas (renewable fuel produced when organic materials such as food scraps and animal waste break down) that has carbon dioxide and impurities removed as biogas itself cannot be used for direct heating due to impurities.

Biomethane is seen as a key 'drop-in' solution to avoid extensive process redesign, potentially as a transitional step towards longer-term hydrogen use. Biogas offers an almost functionally identical, low-disruption alternative to natural gas and could be delivered through the existing gas network with relatively minor process adjustments. This may allow a phased transition option as blending levels could gradually increase from partial substitution to 100% as network availability and production capacity develop.

Availability and cost are significant limiting factors to firms using biomethane. Some ceramics stakeholders highlighted that the availability of bio-fuels is often constrained for them as availability is often targeted towards 'prioritised' sectors and applications. **Ceramic**s producers need long-term energy supply security to readily operate their long-term production processes. Firms also raised questions about NOx (see more above) and trace contamination in biomethane, and if these could affect product quality or become trapped in **ceramics** materials.

Fuel switching also cannot be undertaken without trials. In particular, certain **ceramic** products are highly sensitive to firing conditions, even small changes in fuel composition can affect product quality in various ways depending on the type of product (such as colour constraints for brick). Biomethane may also be a concept new to them. Companies may need controlled testing to ensure biomethane does not alter material properties or performance. This is not just a quality risk but also a cost and timeline risk, where controlled testing for new fuels typically requires dedicated kiln trial time, which is a scarce and expensive resource for SMEs running kilns at or near capacity, and is rarely accounted for in the headline cost of fuel-switching.

Biomethane is an option many **glass** firms are actively considering as a substitute for natural gas, given its near-identical combustion behaviour, full compatibility with existing pipeline infrastructure, ease of integration, and ability to deliver emissions reductions without large-scale modifications to existing furnaces. For example, Saint Gobain Glass and Riou Flat Glass were able to successfully integrate locally produced biomethane into their flat glass manufacturing process in France. The biomethane was produced from agricultural materials and transported via road through by tanker truck to a central site or directly to an industrial consumer site.[17]Although certification mechanisms such as Renewable Energy Guarantees of Origin (REGOs) are still being developed, commercial models, such as those offered by Future Biogas[18], already enable the purchase of biomethane. Currently, the unsubsidized cost to the industrial consumer sits at around £100 per megawatt, with subsidised biomethane currently retailing at approximately £50 per megawatt. Although this may provide a potential contractual route, it is unlikely to be feasible as costs would rise significantly – likely more than double – for most operators at this price and would be unlikely to offer any payback. Under UK ETS, a likely £10 credit given current prices.

Participants highlighted specific regional opportunities. In Northern Ireland, biomethane is particularly promising, and industry is actively engaging with government on how production could be scaled. Some firms are exploring biomethane as a contingency option - one noting that if hydrogen negotiations were to fail or if hydrogen infrastructure timelines are delayed, they would seek to secure greater volumes of grid biomethane if it were to be recognised under the UK ETS.

However, currently grid biomethane is not zero-rated under the UK ETS. Contractual mechanisms without physical delivery to the site as long as the correct quantity of fuel is injected into the system, could support this flexibility and allow firms to reduce emissions without waiting for local infrastructure upgrades. This model is already well-established for renewable energy certificates, where all grid users can benefit from

[17] Methagora. 2025. "Industrial Decarbonization: Saint-Gobain Glass Goes for Biomethane in Flat Glass Production." Methagora.Com. Methagora. December 3, 2025. https://www.methagora.com/en/blog/decarbonation-industrielle-saint-gobain-glass-biomethane-porte.

[18] RGGO Auction to Add Transparency," *Argus Media*, January 30, 2025, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2652627-q-a-uk-s-biomethane-rggo-auction-to-add-transparency.

decarbonisation regardless of proximity to the generation source. A certificate mechanism could allow industries to benefit from biomethane produced elsewhere.

3.1.5 Carbon Capture Utilisation and Storage (CCUS)

CCUS is a potential long-term option for some facilities in the sector, which could allow continued use of natural gas without requiring fundamental changes to core processes.

Adding capture equipment can, in principle, be combined with existing combustion systems to make CCUS one of the least disruptive technical options, albeit with much more significant associated infrastructure, land requirements and other regulatory implications. However, stakeholders expressed concern with CCUS being economically viable as it would require significant improvements to the flue gas abatement system and is predominantly available only for large plants and large concentrations

Firms reflected on broader strategic questions surrounding CCUS - noting that there is a lack of clarity on if CCUS will be recognised as a feasible, commercially viable long-term route for these sectors, or if it will be viewed only as a supplementary measure. Stakeholders drew comparisons with the cement sector, where CCUS is being actively pursued as the primary decarbonisation route due to the extent of their process emissions and much larger, concentrated emission sources (making it more viable, albeit still significantly costly), allowing continued use of natural gas whilst capturing emissions. Although stakeholders considered these wider considerations, process emissions from **ceramics** and **glass** are much less than in sectors such as cement.

Significant additional infrastructure would also be required on site for capture, meaning a need for additional land around factories, and CCUS itself is a far-more complex chemical process than the product manufacturing process itself. CCUS is also dependent on the development of new infrastructure to transport and permanently store captured carbon emissions. The distribution of sites away from industrial clusters further limits potential uptake, while the availability and timing of third-party infrastructure remains a contributory barrier to CCUS viability as a decarbonisation route.

3.2 The Economic Context

Decarbonisation across all new pathways will require significant and sustained investment. For most pathways, the projected paybacks are low (if even positive), highly uncertain, and/or may only be realised very late in the assets (long) life. When these economic risks are paired with current high levels of policy uncertainty, the overall investment environment becomes extremely challenging. The cost of finance, both equity and debt, rise accordingly. Investors simply do not invest or seek alternative locations where there is a more stable policy framework and shorter anticipated payback periods.

3.2.1 Investment and Funding

Attracting investment to UK industry is becoming increasingly difficult. The UK is often overlooked for investment due to high energy costs, carbon costs and regulatory barriers.

High upfront cost, long payback periods and tight operating margins mean that many projects are only viable with government support. The Industrial Energy Transformation Fund (IETF) played a critical role in enabling deployment by covering up to 40-50% of capital costs, reducing risk and shortening payback periods. This significantly reduced financial risk and enabled investment in efficient technologies like heat pumps or efficiency improvements. However, the discontinuation of the second competition window of

Phase 3 of the IETF with no successor fund planned, has created a significant funding gap, leaving companies without a mechanism to support deployment-ready technologies.

Many projects in **ceramics**, particularly in the refractories sub-sector are only viable with this level of capital support and the funding cliff-edge removes a key mechanism for deployment-ready technologies just as firms need it most.

Operational costs further complicate investment decisions. Even when low-carbon technologies reduce energy consumption, they may rely on more expensive fuels like electricity or hydrogen. Without ongoing support to manage these higher operating costs, firms risk being uncompetitive, especially as lower-cost imports set tight constraints on the achievable end-product prices.

Glass firms also face distinct pressure linked to their global ownership structures. Many sites are part of multinational groups that allocate capital internationally. Funding schemes such as the IETF were key to making UK plans competitive for investment relative to where stronger support is available such as in Europe, with the EU Innovation Fund, carbon Contracts for Difference (CfD) schemes and grant funding for decarbonisation from individual member states.

The **ceramics** sector has unique funding challenges due to its predominantly micro-SME composition with associated limited capital reserves, thin margins, low capacity to absorb risk and limited resource to progress bids or explore opportunities available.

3.2.1.1 Long Asset Lifetimes

Many of the assets used in the sectors are characterised by their long asset lives:

- In the **glass** sector, furnace rebuild cycles typically span 10-20 years, and decisions about the next rebuild cycle are made several years in advance. Once a technology is chosen, it becomes very difficult to change course. High upfront capital costs and uncertainty about future policy and infrastructure create a difficult investment environment. As a result, many firms choose not to invest, even when decarbonisation is technically feasible for their site. For example, glass company A recently invested $150 million rebuilding two furnaces. With a 15–20-year change-out cycle, the company is effectively locked into its current technology until the late 2030s or early 2040s. While incremental improvements may be possible in the meantime, the next major technology decision will not occur for more than a decade.

- In the **ceramics** sector, the challenge is even more pronounced as kilns have lifetimes of 30-50 years, meaning that investments made today will likely still be operating beyond 2050. Ceramics company F highlights that for them, a single kiln may cost around £15 million, and an equivalent electric one could cost double. Committing that level of capital investment would require complete confidence that the investment will remain technically and economically viable over several decades. NB: this should not be taken as a representative cost of kilns used across the sector; costs are highly-variable.

3.2.2 Economics of Energy Efficiency and Waste Heat Recovery

High upfront costs and long payback periods often make projects infeasible without support. Several **ceramics** firms had included energy efficiency and waste heat recovery projects in their transition plans under the assumption that IETF funding would be available. The availability of upfront capital made these projects viable by helping with cashflow and reducing payback periods. Where funding was not secured, most of these projects had to be removed from transition plans.

3.2.3 Economics of Electrification

3.2.3.1 Electricity Costs

The UK's industrial electricity prices increase running costs to a level that makes electrification commercially unjustifiable. High capital costs when converting to electric technologies compound this challenge, particularly for equipment and in some cases, redesigning fundamental infrastructure.

Many investments require new or upgraded connections, but even very short connection distances can involve extremely high capital costs and long lead times. These cost differentials, combined with the risks and delays inherently, undermine the feasibility for many firms to electrify. Despite this, it is the primary decarbonisation route for UK and EU **glass** producers, as it is the most technically viable and efficient route.

Some policy progress has been made for the **glass** sector with the introduction of the Supercharger scheme which gives manufacturers 100% exemption from environmental levies and capacity market charges. More recently the Network Charging Compensation (NCC) element of the scheme has increased from 60% to 90% as part of the British Industry Supercharger scheme. This has helped narrow the gap between gas and electricity prices, however, more could be done by aligning with the EU and compensating companies for the indirect carbon costs passed through on electricity.

Ceramics producers, by majority, currently do not qualify for the same level of support, significantly weakening the business case for electrification in the sector, particularly for high-temperature processes where electricity costs would be several times higher than natural gas. This is one of the most significant issues for **ceramics** firms and would leave businesses to absorb all conversion costs, and higher onward operating costs, something that most would not be able to do and continue to compete on their respective markets.

3.2.3.2 Grid Capacity and Infrastructure

Electrification requires a significant, sustained supply of electricity. Many local grids cannot deliver the multi-fold increase in electricity required for electric kilns and furnaces. Many sites would require upgraded distribution connections and in some cases transmission connections. The timelines for the provision of these by network companies can stretch into multiple years or even decades. Even very short connection distances would require extremely high capital costs and long lead times.

While some firms are exploring on-site generation to reduce reliance on the grid, relieve grid pressure and accelerate decarbonisation, they face complex grid rules, permissions and administrative hurdles that limit deployment.

Some firms described challenges beyond cost and basic grid reliability. **Glass** company B, located in a rural area reported that its existing electricity supply is already unreliable, having been historically overlooked for infrastructure investment. Securing the level of power needed is not feasible without building substantial on-site generation and storage. Battery storage would be key to maintaining stable operations but involves further cost and impacts commercial payback. Even if electricity prices fall, electrification cannot happen without a secure and resilient energy supply.

3.2.3.3 Volatility of International Energy Markets

Volatility in UK and global energy markets and supply-chains also pose a significant risk. For example, the surge in gas prices and other economic impacts in light of the war in Ukraine (and conflict in Iran) have directly and indirectly contributed to several plants being forced to mothball or shut down over recent years, either due to production cost increases or market downturns. This results in loss of local economic and employment benefits, as well as undermines UK supply chain resilience. This shows the vulnerability of energy-intensive industries to geopolitical events and shocks, highlighting the importance of stable, affordable energy supplies as part of any decarbonisation pathway.

This is a key issue for the **ceramics** sector as most firms in the sector are not eligible for various government support on energy costs and are fully exposed to high UK costs, unexpected geopolitical shocks, with natural gas still being the primary energy source for most operators and also a significant factor influencing UK electricity prices.

3.2.4 Economics of Fuel Switch to Hydrogen

3.2.4.1 Infrastructure Gaps

The lack of a national hydrogen supply chain prevents fuel switching to hydrogen being technically accessible and commercially viable for firms. Even if hydrogen-ready burners were installed, there is currently no way to procure the fuels in a viable manner.

In stakeholder engagement the following issues were also reported:

- Even where regional hydrogen pipelines are proposed, they often do not pass close enough to key industrial sites (particularly in highly dispersed operations). This is a significant practical barrier for dispersed manufacturers. Site location for **ceramics** manufacturers (such as refractories manufacturers) is often historically determined by proximity to raw materials or labour, not industrial clusters or planned hydrogen infrastructure. Many sites are structurally unlikely to receive an early connection, regardless of how the wider hydrogen economy develops. For example, Parkinson-Spencer Refractories is a long-established business with origins dating back 225 years, operating from the same site throughout its history.

- Transporting hydrogen by road is not feasible at the scale required for large furnaces or kilns. This effectively rules out hydrogen as a near-term option for any site not connected to a hydrogen gas grid/pipeline network. This leaves such sites dependent on continuing with natural gas regardless of their own readiness to convert.

- For sites located near residential areas, storing hydrogen on-site may raise additional safety and regulatory challenges, particularly as long-established sites are historically closer to residential developments. The on-site space needed for tube trailers can also be a prohibitive factor for space-constrained sites.

- Hydrogen clusters are developing unevenly across the UK, with Scotland being left outside of major infrastructure corridors. This raises the risk of regional competitive imbalances, where firms located in hydrogen clusters become more attractive to customers seeking to reduce product-level emissions. This risk applies to any site off cluster (including many English sites such as Parkinson-Spencer Refractories, which are not located near industrial clusters). These sites face the same competitive disadvantage as in Scotland relative to clustered competitors.

- Ceramics company D is actively exploring early hydrogen conversion. However, hydrogen currently remains multiple times more expensive than natural gas, and the lack of a developed hydrogen industry limits access to suitable technology and expertise.

Without clear government commitment to infrastructure timelines, manufacturers cannot make informed capital decisions about hydrogen-ready equipment now, since the payback depends entirely on infrastructure that may or may not materialise on a usable timescale.

In Europe, the EU Green Deal has accelerated hydrogen deployment[19] as several small companies are already producing hydrogen using electrolysers for local industrial use, supported by clear policy direction and strong

[19] European Hydrogen Observatory. “EU Hydrogen Strategy under the EU Green Deal.” European Hydrogen Observatory, 2025. https://observatory.clean-hydrogen.europa.eu/eu-policy/eu-hydrogen-strategy-under-eu-green-deal.

market signals. In the UK, the Hydrogen Allocation Round (HAR) aims to support hydrogen production, allocating Hydrogen Production Business Model (HPBM) revenue to support funding successful projects over 15 years to make hydrogen more cost-effective. HAR1 supported 11 green hydrogen projects, and these projects are all expected to become operational by the end of 2026, with 27 electrolytic hydrogen projects shortlisted for HAR2.[20]

3.2.4.2 Alternative Market-Based Approaches

Market-based mechanisms could offer a more efficient and flexible approach without physical hydrogen pipelines to enable industrial fuel-switching. Participants suggest alternative market-based approaches which may offer a more efficient route to decarbonisation than physically transporting hydrogen through the gas network. In principle, companies should be able to pay a producer to generate low-carbon hydrogen and receive the associated emissions credits, as long as the correct volumes are physically injected somewhere into the network. As mentioned previously, this model is already well-established for renewable energy certificates, where all grid users benefit from decarbonisation regardless of proximity to the generation source.

This is already tried and tested for renewable electricity credits. In such a system, all users connected to the grid would benefit from the carbon reduction, regardless of their proximity to the point of injection. However, any such mechanism must be cost-effective. If hydrogen or hydrogen-linked credits significantly increase fuel costs, manufacturers risk pricing themselves out of the market, especially when competing with imports from competing countries with lower energy prices.

In some regions, highly efficient hydrogen production could be technically viable using local renewable or waste heat resources, but current regulations do not allow companies to inject privately produced hydrogen into the grid or participate in a credits-based system. A certificate mechanism could allow industries to benefit from low-carbon hydrogen produced elsewhere.

3.2.5 Economics of Fuel Switch to Biomethane

Several firms felt that biomethane could be the simplest, most practical short-term decarbonisation pathway, but without clear government decisions on ETS recognition, firms cannot necessarily plan for biomethane use. Under current UK ETS rules, biomethane delivered through the grid cannot be zero-rated, meaning firms cannot claim the full carbon benefit. Government has indicated support in principle for a zero-rating for biomethane, but progress has been slow[21].

As mentioned previously, several firms felt the first key step is for government to recognise biomethane within the UK ETS. In contrast, EU operators use biogas certificates to offset ETS costs, creating a significant competitiveness gap that is already influencing investment decisions. Given that the UK is also planning to use EU ETS benchmarks, which are reducing, the fact that biomethane is not recognised under UK ETS also produces a UK ETS cost and competitiveness gap.

Biomethane also carries a significant price premium over natural gas as switching on the open market would add approximately €30-40 per MWh – an increase many businesses would not be able to absorb. There is a need for mechanisms to stimulate supply and reduce the price difference in comparison to natural gas, to support large-scale biomethane supply chain. Firms need confidence that biomethane will be available long-term, at scale and at predictable prices before committing to multi-year contracts.

[20] Department for Energy Security and Net Zero, "Hydrogen Allocation Rounds," GOV.UK, accessed September 16, 2026, https://www.gov.uk/government/collections/hydrogen-allocation-rounds

[21] Swan Energy Ltd., "UK Government Explores Including Grid Injected Biomethane in ETS," September 16, 2025, accessed April 10, 2026, https://swanenergy.co.uk/biomethane-uk-ets/.

In addition, although direct pipelines benefit from zero emissions, proximity to a supplier or building and managing production and storage of biomethane on sites are also key barriers for firms using biomethane.

3.2.6 Economics of Carbon Capture and Storage (CCS)

The economics of CCS is largely dependent on the development, availability and cost of third parties investing in large scale carbon pipelines, shipping terminals and geological storage. The economics are also dependence on site-specific on-site costs. These assets do not exist for most sites in the **glass** and **ceramics** sectors, most of which are located outside of industrial clusters. Without this, firms are forced to consider localised capture and storage solutions, an option which remains prohibitively expensive and technically unrealistic for dispersed sites.

CCUS will not be a universal sector solution and is not yet technically viable for the **glass** sector. Given the level of investment that would be needed, as well as associated logistical impacts. Indeed, CCUS costs at present are prohibitively expensive for companies to move this forward.

3.3 The Competition Context

Market demand for low-carbon products remains weak across **both sectors**. Customers are rarely willing to pay a premium for low-carbon products, even when manufacturers face higher operating costs from fuel switching or efficiency upgrades. In highly price-sensitive markets, UK producers cannot pass higher operating costs associated with low-carbon technologies to customers. Some manufacturers noted that their customers are themselves facing downturns, restructuring and shifting market dynamics, reducing their ability to support or demand low-carbon products and conversely may turn to lower-cost goods.

3.3.1. International Competition

International competition is a defining challenge shaping investment decisions. UK firms operate in a highly globalised market where customers prioritise cost and where lower-priced imports, often produced under more favourable energy prices and regulatory conditions, set the standard. UK producers are increasingly vulnerable to displacement by cheaper imports as these are increasingly entering the market at prices that undercut domestic producers who face rising energy costs and tightening environmental protections.

Ceramics firms specifically compete against manufacturers in regions with lower production costs and fewer decarbonisation regulations. Margins in overseas markets, such as Asia, are substantially higher. The UK ceramics sector runs a persistent trade deficit of around £1 billion, reflecting competitive pressures and limited capacity for large-scale modernisation[22]. **Ceramics** refractory producer Parkinson-Spencer Refractories notes that UK producers face additional tariffs and cost add-ons that their European and North American competitors do not, undermining competitiveness of domestic production.

In the **glass** sector, some sub-sectors such as container glass are facing a drop in demand. Compounded with high electricity costs, companies which operate globally are considering where it is possible to close sites, risking UK site closures due to prohibitive costs and reduced demand.

Firms across **both sectors** warned that without a more competitive operating environment, the UK risks accelerating carbon leakage. Production, and investment will shift overseas while consumption emissions in the UK will not reduce or even increase.

[22] Khalil, A. M. E., Velenturf, A. P. M., Ahmadinia, M., & Zhang, S. (2023). Context Analysis for Transformative Change in the Ceramic Industry. Sustainability, 15(16), 12230. https://doi.org/10.3390/su151612230

3.3.2. Competition from Alternative Materials

Competition from alternative materials is also intensifying. Recent UK packaging reforms, favour lighter materials such as plastic and aluminium, despite poorer sustainability and environmental performance.

Under the Producer Responsibility Obligations (Packaging and Packaging Waste) Regulations 2024, the current methodology for calculating Extended Producer Responsibility (pEPR) fees places a disproportionate burden on **glass**, due to its high weight-to-unit ratio. As fees are driven by the tonnage of material placed on the market, glass brands face substantially higher costs relative to plastic or aluminium producers. This approach fails to account for the full lifecycle value of glass. Unlike many competing materials such as plastic and aluminium, glass can be infinitely recycled and reused without degradation - a characteristic that should be central to any circular assessment. Total circularity and material longevity must be factored into the fee methodology if the regulations are to be truly reflective of environmental impact. These policies are already driving some producers in the UK, to switch from glass bottles to plastic bottles or cans purely due to cost or import glass from other countries.

Both glass and ceramics also face competition from alternative materials in the construction sector that offer lower costs or easier installation, placing additional pressure on market share.

3.4 Logistics and Practicalities

3.4.1. Site Space and Downtime

Many UK industrial sites are decades, or even centuries old, with layouts that have evolved incrementally over time. This creates significant challenges, for example:

- Integrating new technologies that require different building configurations, power supply and safety zones
- In dense residential areas, many companies face severe space constraints as new technologies often require additional footprint

For the **glass** sector, converting to electric melting requires extensive work to the site due to a fundamentally different layout and footprint. For the **ceramics** sector, large tunnel kilns can be up to 200 metres long in some locations, and firms lack the spare space to install a replacement before replacing the old unit.

Limited regulation capacity and slow permitting processes add to the cumulative burden, especially when multiple decarbonisation and compliance projects must be delivered simultaneously. Ongoing reviews of BAT and environmental permitting conditions may tighten emissions limits in the 2030s. If new limits require additional abatement and equipment, this could impose further space, cost and installation compliance challenges on already constrained sites.

Batch kilns are designed to produce in distinct, separate batches which are each individually loaded and go through a full cycle of loading, heating and unloading. Continuous kilns and furnaces operate uninterrupted, and production is ongoing as raw materials are constantly fed through, processed and exit at the other end[23]. Unplanned shutdowns of kilns, particularly continuous kilns (e.g. due to energy availability constraints) could lead to significant damage to kilns in the order of millions of pounds and production losses as even small changes to firing conditions can affect product quality. For example, one firm illustrated how unplanned downtime can be catastrophic, losing hundreds of tonnes of **glass** due to a furnace leak. When decarbonisation projects require extended shutdowns, the commercial risk becomes significant. This makes

[23]Kintek. 2026. “What Are the Differences between Batch-Type and Continuous-Type Rotary Kilns? Choose the Right Kiln for Your Production Needs.” Kintekfurnace.Com. Kintek Furnace. https://kintekfurnace.com/faqs/what-are-the-differences-between-batch-type-and-continuous-type-rotary-kilns.

companies highly cautious about adopting technologies that require long installation windows or complex commissioning processes.

When switching off continuous kilns in **ceramics**, operational efficiency is lost by losing thermal energy stored in the air and in the structure, therefore fuel and throughput time is also lost. Switching off a **glass** furnace could potentially even cause physical damage to the furnace itself as the cooling of a furnace risks solidifying molten glass, which can cause structural damage to the furnace internally. Although advanced furnaces can be turned off for up to an hour, switching off has to be done in a very controlled manner to ensure the glass is kept liquid.

3.4.2. Equipment Transport and Customs

Transporting large industrial components is a major logistical challenge which relies heavily on specialist refractories and furnace equipment manufactured in Europe. Companies reported that customs delays and post-Brexit border processes can add weeks to delivery times, directly affecting repair schedules and project timelines. Glass company A noted that equipment that could previously be delivered in two days now takes two to three weeks, delaying furnace repairs and extending costly downtime.

Ceramics manufacturers also noted that sourcing large-scale tunnel kilns or bespoke components may require international suppliers, adding complexity, cost and uncertainty to project planning. These supply chain constraints increase the risk profile of decarbonisation investments, may hinder R&D projects, and can make firms reluctant to commit to any major technology change.

3.5 Policy and Regulation

3.5.1 Short-term Policy Frameworks

Current policy frameworks often prioritise short-term carbon metrics rather than consider whole-life product sustainability. This is particularly challenging for **ceramics**. Clients and local authorities increasingly ask for Life Cycle Assessments (LCA) or verified Environmental Product Declarations (EPDs), yet the use of information often fails to accurately reflect the true performance of **ceramics** products over their full lifetime. Building Lifecycle Assessments (which EPDs are used towards) typically assess environmental impacts over a 60-year period, despite products such as clay bricks being designed to last at least 150 years. This means that longer-life products can appear less- favourable in a shorter-term perspective, versus alternative product choices of a shorter lifespan, lesser durable, higher maintenance requirements. Producing verified product-specific EPDs is resource-intensive and expensive, therefore extremely challenging for SMEs, and companies with extensive product ranges.

The emphasis on achieving the lowest possible embodied-carbon at the point of production encourages a short-term thinking in policy and market attitudes. The cheapest materials are often prioritised as well as the desire to advertise the lowest ‘headline carbon’ figure to sell products, even if this undermines long-term durability and sustainability. This issue is reinforced by market pressures that reward short-term cost savings over long-term environmental benefit.

Glass firms share similar concerns of long-term policy cohesiveness and clarity, noting that decisions on construction standards, insulation requirements and material regulations such as the Future Home Standards (FHS) change regularly. **Glass wool** firms in particular, argued that the move away from a “fabric-first” approach would be disastrous for UK emissions and long-term efficiency.

This reflects a need for a fundamental shift in policy design away from short-termism towards more sustainable whole-life durability and circularity criteria. Policy itself must be long-term since frequent policy

changes and inconsistent cross-departmental coordination create a high-risk environment that discourages investment.

Firms would welcome clarity on whole life carbon limits for buildings as the EU aims to improve the energy performance of buildings through the Energy Performance of Buildings Directive (EPBD)[24]. This would set a demand from customers as they will need to meet certain levels of energy performance. Without a customer pull factor the UK will fall further behind as this adds to the funding competitiveness issues and internal company funds will be invested elsewhere where there is a driver.

3.5.2 Policy Fragmentation

Energy policy, industrial strategy, environmental regulations, construction standards and trade measures are often developed in isolation, with conflicting objectives, creating contradictory signals for businesses. Firms must make decisions on assets with lifecycles of 15-20 years for **glass** and 30-50 years for **ceramics**, but policy uncertainty means a chosen technology could be rendered uneconomic by future regulatory changes. For example, a highly efficient gas kiln carries risk if future policy shifts make gas significantly more expensive relative to electricity to incentivise electrification, where gas-intensive businesses may be unable to fuel-switch from gas for various techno-economic reasons.

Production naturally gravitates towards countries where policy is more stable, incentives are clear and returns are more predictable. Stakeholders described a system where government departments have limited assessment of how various policies interact, describing the situation as “whack-a-mole” policymaking, policies solving one issue only for another to emerge elsewhere.

3.5.3 Complex Policy and Government Schemes

Several existing schemes are overly complex and impose disproportionate administrative requirements relative to their impact. For example, under the UK ETS, firms must verify emissions down to granular levels, including minor sources, despite these being negligible compared to kiln emissions. Companies felt this was an unnecessary burden that is time-consuming, expensive and adds little value to emissions reduction.

Repeated government commitments to streamline energy and climate reporting requirements have continued to not translate into tangible improvements, and in fact schemes continue to grow in burden for energy-intensive industries. Firms face duplicate data requests and inconsistent methodologies across departments resulting in increased resources and compliance costs.

3.5.4 International Policy - Carbon Border Adjustment Mechanism (CBAM)

Carbon leakage remains a major strategic risk. While neither sector opposes a CBAM, they felt that any mechanism must be based on robust carbon data and implemented in a way that considers specific product characteristics. **Both sectors** asked to be removed from the initial scope of the UK CBAM for these reasons.

A central concern across sectors was that the CBAM could become a vehicle for reducing or removing free UK ETS allowance before a credible mechanism is in place. If domestic manufacturers lose free allocation whilst competing against imports, UK producers could face higher cost without equivalent protection, increasing, rather than preventing, carbon leakage. Calculating embodied carbon in imported goods is technically complex and without reliable data, CBAM risks distorting markets rather than levelling the playing field.

[24] European Commission, “Energy Performance of Buildings Directive,” European Commission – Energy, accessed June 17, 2026, https://energy.ec.europa.eu/topics/energy-efficiency/energy-performance-buildings/energy-performance-buildings-directive_en.

CBAM must be grounded in UK-specific data, designed to prevent carbon leakage in a way that does not push production overseas. For example, the imports in the **ceramics** sector have already increased to a point where they currently dominate. Meanwhile domestic production has declined.

Ceramics firms feel that UK trade patterns differ significantly from those in the EU. Simply mirroring the EU CBAM rules may not reflect UK realities. They also noted that it is difficult to accurately assess the embodied carbon of imported **ceramics**, given the lack of transparent international data and the diversity of global production routes. If CBAM is based on inappropriate or non-representative data, such as EU benchmarks applied to UK conditions, it could undermine competitiveness.

On the other hand, **glass** firms warned that a standalone CBAM, implemented without close EU alignment risks competitive distortions for their sector. **Glass** products have unique characteristics – such as high recyclability, diverse product categories and complex supply chains, that require careful consideration in CBAM design.

As mentioned above, the **glass** sector successfully lobbied for removal of the first round of the CBAM due to the complexity of applying CBAM to **glass** products, as manufacturers warned that glass-specific qualities need to be considered. For example, a CBAM applied only to empty **container glass** would incentivise and encourage producers to fill bottles outside the UK and import them to avoid a tariff. This would make domestic production more expensive and undermine competitiveness without reducing global emissions. There are also concerns on material substitution for the **glass** sector. If a CBAM is applied to **glass** but not to competing materials such as plastic or aluminium, it could raise the relative cost **glass** packaging and push manufacturers and brands towards higher-carbon alternatives.

3.6 Policy Recommendations from Stakeholders

Despite the barriers discussed, stakeholders identified opportunities to overcome these challenges, reduce emissions and strengthen long-term competitiveness through targeted policy measures.

3.6.1 Energy Economics and Contracts

Decarbonisation will not be possible without addressing energy costs as manufacturers will significantly struggle to absorb higher costs from fuel switching or efficiency upgrades. A variety of policy tools were discussed and seen as essential to making (more costly) low-carbon fuels and electrification financially viable for the sector. Bringing down the cost and ensuring availability of electricity and alternative fuels such as hydrogen and biogas was a key priority for firms looking to fuel switch in the near future. Targeted energy cost support would **allow firms to move away from using natural gas and unlock viability for electrification and alternative fuels.**

For both sectors, the **upcoming review into eligibility for the British Industry Supercharger Scheme will be critical and is fundamental to competitiveness,** whether for currently eligible companies in **glass** and **ceramics** to retain this support, or for eligibility to be extended in **ceramics** to cover far more companies than presently.

Changing biomethane's "zero-rating" in the UK ETS is a top priority for firms who also proposed a biomethane Purchasing Power Agreement (PPA) model, similar to green electricity PPAs. Companies could contract for biomethane quantities, regardless of where it was used in the system to bypass infrastructure constraints, **provide long-term price certainty** and allow firms to **contribute to national decarbonisation even before local pipeline upgrades take place.** This would **allow biomethane to be a viable option** for many **glass** firms who are seriously considering this decarbonisation pathway.

A Contract for Benefits (CfB) could capture wider environmental and economic gains, rather than focusing solely on price difference. This could help focus on total lifetime emissions and **encourage investment** more generally by **giving producers and/or users the greater certainty** provided by a contract as opposed to a regulatory incentive scheme.

3.6.2 CapEx and OpEx Support

Upfront capital support is key for deploying even proven technologies:

- The scale of investment required is far beyond what many companies can finance alone
- Firms need support managing the finances associated with long-term offtake contracts and major infrastructure changes
- Many sites cannot electrify without major upgrades to local networks, on-site infrastructure and grid connection support

Without immediate intervention, companies will invest in the electrification of their sites outside of the UK and electrification will stall regardless of technological readiness.

Support for OPEX OpEx was seen as a key complementary policy to **continue supporting projects** as costs of running low-carbon equipment remains unaffordable. Firms emphasised that the end price of electricity for industrial users must reduce to a point where electrification is economically feasible. Firms felt that the UK ETS revenues could be used for this [NB The Treasury does not tend to hypothecate (ring-fence or earmark) tax revenues, i.e. not create explicit links between how money is raised and spent]

Operators contribute significant sums into the system through the UK ETS, however, there is little transparency about where this money ultimately ends up. Recycling UK ETS revenues back into the industry through funding grants, capital support, or innovation funding, would provide an impactful way to accelerate projects and avoid the ETS functioning simply as a tax. Rather, there is an opportunity for the ETS to be a transition tool by using at least some of the revenues raised from the ETS to create a stable, long-term funding stream for decarbonisation projects for industry. This would enable ETS revenues to be channelled into a dedicated, ring-fenced mechanism to support deployment, research and help firms invest in low-carbon technologies and efficiency upgrades. By reinvesting revenues into a structured programme of CapEx and OpEx support, the ETS could shift to a strategic lever and strengthen competitiveness by ensuring that UK firms can access the same type of funding available in Europe and other regions with more financial support frameworks.

This approach could operate as a technology-neutral mechanism, ensuring that firms can apply for support and select the low-carbon option that best fits their specific circumstances and processes. Such a model would be fully aligned with industry needs and allow flexibility to support both large firms and first-movers, as well as SMEs with specific barriers. For many firms, targeted CapEx and OpEx support would be a decisive factor enabling investment in electrification, hydrogen, hybrid systems or efficiency upgrades. For other firms (particularly SMEs in ceramics), the priority may be research and early-stage development. This approach would ensure tailored support for each firm and site.

Strengthening capital support mechanisms would ***provide a mechanism to continue decarbonisation projects that may have previously stalled****. Targeted capital grants and carbon-reward mechanisms would* ***reduce risk by creating a more predictable investment environment for long-lived assets*** *such as kilns and furnaces. This could play a critical role in* ***levelling the playing field between the UK and EU for investment competition*** *and* ***preventing investment leakage*** *out of the UK.*

3.6.3 A Coherent, Long-term Policy Framework

Decarbonisation requires a long-term, stable and straightforward policy environment. Predictable policy is key to **de-risk investment** and **encourage investment for UK firms**. A coherent, cross-government UK Foundation Industries Strategy, supported by clear ownership, stronger departmental coordination and a dedicated minister or champion, is an opportunity to **align energy, environment, construction, trade and industrial policy.**

Firms also called for simpler regulatory frameworks with consistent definitions, streamlined reporting requirements and verification processes that reflect the realities of high-temperature manufacturing. Decarbonisation support must be accessible, particularly for SMEs that lack dedicated compliance teams. This is a key opportunity as clearer, more consistent regulation would **remove unnecessary administrative burden, lower compliance costs,** particularly for SMEs with already thin margins, **and allow firms to focus resources on decarbonisation efforts** rather than navigating complex paperwork and regulation.

3.6.4 Use of Contracts

Output-based mechanisms such as Contracts for Difference (CfDs) have been used to **accelerate investment by reducing the policy and regulatory risk** associated with taxes, levies, incentives and obligations which can be readily changed. Using a contractual basis instead **can give firms more confidence to invest at scale, especially in long-term assets**.

Other output-based contracts could be a **powerful, technology-neutral tool to reward genuine decarbonisation, providing the long-term certainty needed to deploy technologies across sectors,** from large industrial processes to agricultural and rural bioeconomy systems.

Unlike schemes that stabilise costs or subsidise technologies, a Contract for Benefit or for Output could guarantee a reward for achieving verified carbon reductions**, creating a bankable revenue stream** and a **direct incentive to decarbonise**. Firms and farming enterprises alike could borrow against future contracted returns, making it **significantly easier to finance low-carbon technologies** at any scale.

This approach has particular resonance for agricultural biomethane production. Research in Northern Ireland has shown that farm waste feedstocks alone could displace a substantial share of fossil gas demand across Great Britain[25]. A Contracts for Benefit framework - tiered by carbon permanence and feedstock type, with projects competing through an auction process - could unlock exactly this kind of investment, giving rural cooperatives and community-scale producers access to the revenue certainty that larger industrial players take for granted.

European precedents demonstrate that output-based carbon mechanisms work at scale:

- The EU ETS delivers a direct financial benefit for verified emissions reductions, with over €230 billion raised through auctions since 2013[26]
- The EU Innovation Fund links support to verified emissions reductions at the point of delivery[27]
- The EU Modernisation Fund channels ETS revenue to projects with measurable emissions outcomes in lower-income member states[28].

[25] Centre for Advanced Sustainable Energy (CASE). A Pathway to Our Renewable Future. Accessed September 16, 2026. https://case-research.net/report/a-pathway-to-our-renewable-future/.

[26] European Commission, "Auctioning of Allowances," Climate Action – European Commission, accessed May 5, 2026, https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/auctioning-allowances_en

[27] European Court of Auditors, Special Report 11/2026: Innovation Fund (Luxembourg: European Court of Auditors, 2026), https://www.eca.europa.eu/ECAPublications/SR-2026-11/SR-2026-11_EN.pdf

[28] European Commission, "Modernisation Fund," Climate Action – European Commission, accessed May 5, 2026, https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en

In each case, carbon savings carry tangible financial value, an incentive that continues long after initial investment, and a model with clear potential for adaptation across sectors and geographies.

For **ceramics** manufacturers, this could be particularly valuable as kilns and other thermal equipment often require 20-50 year investment cycles.

3.6.5 Expert Site Visits and Practical Support

As part of a more collaborative approach to sharing best/good practice, expert-led site visits could help identify realistic transition pathways, particularly for SMEs in the **ceramics** sector, who described a need for experts who can review operations, identify realistic pathways and opportunities for burner optimisation, digital controls and modern monitoring systems, provide tailored advice and connect firms to relevant funding partners, or nearby projects.

This contrasts with the experience of schemes such as the Energy Savings Opportunity Scheme (ESOS) in the **ceramics** sector, which was described as often producing recommendations such as insulating buildings or upgrading lighting, but not providing technical help with kilns, missing the largest emissions reductions opportunities. Despite assessment fees of around £10,000, assessments generally did not offer meaningful value and risks wasting the limited compliance budget SMEs allocate to these schemes. This money could otherwise go toward kiln-specific process expertise.

A re-designed programme should be process-focused to target significant emissions reduction and linked to funding to aid firms navigate support. This should be coordinated across government departments to avoid duplication, aligned with wider policy and accessible to SMEs, being low cost and easy to engage with.

This is a key opportunity as expert-led, process-focused support would **give firms, particularly SMEs, the practical guidance** they currently may not have, **helping them identify credible decarbonisation pathways, avoid costly mistakes and missteps in their transition, and access funding with greater confidence.**

3.6.6 Technical Support on NOx Emissions

NOx compliance is a barrier for hydrogen-fired systems where NOx levels are known to increase.

Ceramics firms in particular, emphasised that current NOx limits are based on natural gas combustion and are not directly applicable to hydrogen firing. Hydrogen is being put forward as an emerging technique in the ongoing 'Best-Available Techniques' review for ceramics production as a potential decarbonisation route for adoption, however in the interim, firms face uncertainty about how regulators will treat NOx emission levels. There is currently insufficient industry-wide data for regulators to set new limits or update BATs, creating a period of uncertainty. Specialist technical support could help optimise combustion systems, reduce NOx emissions and integrate abatement technologies. Technical support on NOx should be integrated into wider decarbonisation planning, ensuring firms can adopt fuels such as hydrogen without breaching pollutant limits or facing regulatory barriers.

Resolving NOx compliance uncertainty give **firms the confidence to invest knowing that they are meeting environmental and regulatory standards.**

4. Glass Sector Deep Dive

The UK Glass sector emits 1.5 million tonnes of carbon emissions every year from sites covered by the UK ETS. Current emissions for the sector are vastly driven by:

- Fuel combustion from high temperature melting (typically around 1,300°C – 1,600°C), which account for 75-85% of emissions
- Process emissions from the decomposition of carbonates in raw materials which account for 15-25% of emissions[29]

British Glass reports that 0.749 tonnes of carbon emissions per tonne of melted glass in 2002 reduced to 0.611 tonnes of carbon emissions in 2018, showing the tangible impact of efficiency. British Glass' model also shows that under a full net-zero pathway, 0.074 tonnes of carbon emissions emitted per tonne of output can be reduced from process emissions through increased cullet use, using alternative raw materials, and carbon capture[27].

Despite significant optimisation, most UK furnaces are gas-fired and furnace energy use still accounts for the largest proportion of total sector emissions. Existing gas-fired furnaces cannot be retrofitted for full electrification, meaning that electrification requires complete furnace replacement and investment which has to line up with rebuild cycles. While CVTMs can be scaled through modularisation, there is currently no fully electric technology for horizontal flat glass, and electrifying these furnaces will likely require a hybrid hydrogen-electrification approach.

The forming stage is the second-largest energy consumer and is carried out using Individual Section machines (mostly in the container glass section), which are primarily pneumatic and electrically driven, requiring significant amounts of compressed air. Products are then passed through a gas or electric annealing lehr where glass is reheated to about 650°C and cooled in a controlled manner to relieve internal stresses. Energy use of lehrs is small compared to furnaces.

Further Cold-end operations downstream such as inspection, handling, conveying and packaging are almost entirely electric, contributing to on-site electricity demand.

There is no single decarbonisation pathway for the sector as technology solutions and their maturity varies by sub-sector, product and associated requirements

4.1 Sub-Sector Specific Technical Challenges

4.1.1 Container Glass

Electrification of container glass is currently being used in the form of a typical 6-8% electric boost, where elements of electric heating are used to provide a portion of the energy supplied with examples in the container glass sector of furnaces operating at 80% electric boost[30]. A fully electric and a hybrid furnace have been operating successfully in Europe for several years. This year, several hybrid furnaces will be installed across Europe. Electric furnaces are already common in the manufacture of glass packaging for perfume and cosmetics, as the higher product value makes them economically viable.

[29] British Glass "Glass Sector Net Zero Strategy 2050." (2024) https://www.britglass.org.uk/sites/default/files/British%20Glass%20-%20Net%20Zero%20Strategy.pdf.

[30] "Ardagh Group S.A.." 2023. Ardagh Group S.A. May 23, 2023. https://www.ardaghgroup.com/corporate/news-centre/detail/18705/Ardagh+Glass+Packaging+builds+breakthrough+%E2%80%98NextGen+Furnace%E2%80%99+in+Germany.centre/detail/18705/Ardagh+Glass+Packaging+builds+breakthrough+%E2%80%98NextGen+Furnace%E2%80%99+in+Germany.

Hydrogen is being actively explored as a complementary pathway and some of the world's largest container furnaces have invested heavily in hydrogen R&D[31]. Hydrogen-ready designs are emerging, but full conversion requires smaller, modular furnace configurations. Hydrogen firing also requires modified burner materials and redesigned nozzles to manage higher flame temperatures and different combustion characteristics. While the supply chain can build these furnaces, policy certainty is needed before committing to multi-million pound rebuilds.

Most container glass firms are already operating on 50-60% cullet[32], significantly lowering the energy required and process emissions by displacing carbonate-based raw materials such as limestone and soda ash. However, companies stressed that maintaining colour purity and optical quality, especially for flint (clear) glass, requires strict control of cullet contamination. Using higher levels of cullet is difficult due to quality and more importantly, cullet availability. Firms continue to use virgin raw materials which are blended in electrically driven batch plants before being fed into the main furnace.

Energy efficiency improvements are another major focus. In the UK, there is currently only one batch pre-heater with several more across the EU. Trials suggest potential energy savings of 8-15% for furnaces that can use over a million cubic meters of gas every month.

4.1.2 Flat Glass

Flat glass is an umbrella term referring to all glass manufactured in sheet form, including float glass, laminated glass, tempered and coated products. Within this, float glass refers specifically to the production method in which molten glass is floated on a bed of tin for a uniform thickness, smoothness and excellent optical quality. This is often used in building construction such as windows and doors[33]. This manufacturing process is one of the predominant methods of producing flat glass, for quality and efficiency reasons[34]. Float glass requires a melting heat of up to 1,700°C, followed by the diffusion and dissolution of gas to achieve a homogenous melt. Fully electric furnaces are highly unlikely to be available before 2050.

Flat float glass furnaces rely on drawing glass from the top surface of a large, shallow melt (often holding 1,500 tonnes of molten glass), which requires highly stable thermal conditions and diffusion and dissolution of gas to achieve a homogenous melt to achieve excellent optical quality. Energy must be imparted both at the surface and through the melt. While some container furnaces already use an element of electric boost, flat glass furnaces require a different energy profile, and electrical input accelerates wear and corrosion of furnace components. Constraints are far greater in flat glass than for container glass as well as key quality considerations such as bubble and seed count.

Low carbon fuel switching is more challenging due to horizontal furnaces (which means CTVMs cannot be used) and longer melt times. Electrification is limited to 10-30% of energy input with full electrification expected to be possible from mid-2030s and will likely need fundamental furnace redesign. Increased boosting can make the furnace superstructure electrically conductive, increasing the risk of structural failure. Installing or replacing electrodes is a high-risk operation: drilling into the furnace bottom while it contains molten glass can lead to leaks if not executed perfectly. Long-term decarbonisation likely requires a hydrogen-electric hybrid furnace or CCUS. High-quality cullet supply is a major bottleneck. It is particularly difficult for the flat glass sector to deploy technically viable melting technologies at commercial scale, as they would require reliable high-power supplies which are not currently available. Grid reliability is a key

[31] Encirc, "Encirc MD Welcomes Planning Approval of UK's First Hydrogen Production Facility," Encirc, January 10, 2024, https://www.encirc360.com/2024/01/10/encirc-md-welcomes-approval-of-uks-first-hydrogen-production-facility/.
[32] FEVE (European Container Glass Federation), Glass Packaging Circularity and Cullet (Brussels: FEVE, May 2026), https://feve.org/wp-content/uploads/2026/05/FEVE-position-Glass-packaging-circularity-and-cullet-May-2026.pdf.
[33] AIS Glass. "Flat Glass vs Float Glass: Key Differences, Features & Uses Explained." Accessed June 29, 2026. https://www.aisglass.com/blog/flat-glass-vs-float-glass-understanding-the-difference/.
[34] Nascimento, Marcio Luis Ferreira. 2014. "Brief History of the Flat Glass Patent – Sixty Years of the Float Process." World Patent Information 38 (September): 50–56. https://doi.org/10.1016/j.wpi.2014.04.006.

concern as flat glass furnaces operate continuously, and any interruption risks substantial damage, product loss and major safety hazards.

4.1.3 Glass Wool

Glass mineral wool production presents a distinct set of complex challenges, due to its unique multi-stage process.

Manufacturing glass wool comprises of melting, fiberising and curing. Melting has the same viable low-carbon options as container glass, using 300 ton per day CTVMs. Although electrification is possible for curing ovens, the technology remains at an early TRL. Fiberising currently has no proven solution, although significant R&D is underway by individual firms.

Glass wool manufacturers rely heavily on recycled container glass as a key raw material and some have long-standing partnerships with suppliers to secure this supply of recycled bottles and jars.

Production begins with melting recycled glass and raw materials using natural gas and electricity, melting is still the largest source of emissions at 30-40% of total energy demand. The molten glass is transported through canals to the fiberising section, which relies on a combination of natural gas, electricity and compressed air to create fibres with precise mechanical and thermal properties. These fibres are deposited into a conveyer, coated with a binder, and passed through a curing oven, a long, insulated chamber where hot air forces through the product to set its structure and mechanical properties.

Fiberising is the most technically challenging stage to decarbonise and the second largest source of emissions. With no current viable fuel switching opportunities globally, fiberising is expected to remain a major emissions source in the medium term. Hydrogen is also not technically viable given its combustion characteristics, particularly the calorific value alters fibre properties and compromises product performance.

The process is also highly proprietary with each firm protecting its fiberising Intellectual Property (IP), limiting opportunities for collaborative innovation and knowledge sharing. This means manufacturers cannot produce this equipment at scale for glass wool firms, instead R&D has to be undertaken in-house. Glass wool firms are investing heavily in in-house R&D to explore low-carbon and fuel switching opportunities for this stage.

Curing ovens are another significant energy user where electrification is technically possible but remains at an early TRL. Deployment is tied to long furnace rebuild cycles and electric systems are not yet commercially ready. This makes changing key furnace infrastructure incredibly risky as firms will be locked into the decision for a decade or more, despite changing policy conditions and potential technological advancement. This means the decision may prove to be more expensive in the long-term. Retrofitting is a challenge as ovens are large, insulated structures that operate continuously. Plants typically run for 10 years between major furnace rebuilds, with only short shutdowns every 12 weeks for cleaning. Electrification requires major structural modifications, which cannot be completed during routine maintenance windows.

Given the limited electrification and technical challenges with hydrogen for fiberising and curing, companies view biomethane as an especially attractive pathway to decarbonise multiple process stages simultaneously without requiring major equipment changes or compromising product quality.

A small amount of gas is currently used in shrink packaging operations. Glass mineral wool products are compressible and structurally delicate, meaning packaging plays a central functional role. Glass wool is held within a fibrous matrix. To transport it efficiently, manufacturers compress the product and wrap it in plastic film to maintain shape and protect fibre integrity. Over-compression damages the fibres and reduces product performance, leaving plastic wrapping as the only viable method for maintaining quality during storage and transport.

Glass wool firms are more exposed to packaging-related regulation and costs than other glass sub-sectors and expect to retain a dependency on plastic packaging for the foreseeable future unless a technically equivalent alternative emerges.

4.2 Fuel Combustion Emissions in Glass

4.2.1 Energy Efficiency and Waste Heat Recovery

Energy efficiency and waste heat recovery has also played a key role in emissions reductions in the glass sector. New applications could extend this further. An example raised was the possibility of using recovered heat to support low-cost hydrogen production if industrial waste heat is fully utilised. However, this remains a potential idea at very early stages, rather than a priority or serious consideration by firms.

4.2.2 Hybrid Furnaces

Hybrid furnaces can operate with electricity augmenting natural gas (as currently), hydrogen and biofuels.

Hybrid furnaces combining hydrogen combustion with increased electrical boosting, are emerging. Trials on hybrid hydrogen-electric furnaces show that whilst hydrogen exhibits significant differences in combustion behaviour and flame characteristics (most noticeably that the flame is almost invisible at blends >60%), it delivers a thermal performance and heat transfer efficiency closely resembling natural gas. When fuel-delivery systems and selected refractories are adapted for hydrogen, the overall furnace geometry and operating method remain very similar to standard furnace designs, allowing hydrogen to effectively be a substitute for natural gas. Current electric boosting levels of 6-7% could rise to 20-30%, but this would require major increases in electrical capacity.

One container glass furnaces noted that while their scale is advantageous for demonstrating hydrogen-ready concepts, the commercial risk remains the primary barrier to deployment due to the cost and lack of hydrogen availability. Some firms are negotiating for blue hydrogen supply that could meet up to half of their energy demand. Blue hydrogen is produced from natural gas using CCUS, it is a low-carbon hydrogen route and supported by UK regulatory guidance for emerging production techniques. Firms are also actively exploring green hydrogen options, produced from electrolysis when splitting water into oxygen and hydrogen using renewable energy[35]. However, even optimistic supply agreements fall short of total requirements, as some companies are being offered a maximum of 35 MW of hydrogen, which is less than half of what large container glass firms would need.

Hybrid electric-gas furnaces are seen as the most practical opportunity for combustion emissions reduction route for large-scale float glass production, with early commercial examples already operating in the container sector. Existing hybrid units demonstrate that hybrid designs can scale while retaining conventional furnace geometry and offering flexibility to integrate hydrogen, biomethane or liquid biofuels, as well as potential for limited grid-balancing functionality. Float glass manufacturers consider up to 20% electric boost to be the maximum acceptable level, with higher boosts introducing significant uncertainty around melt stability, ribbon quality and furnace operability. Given the large scale of float furnaces, typically 750 – 1000 tpd, securing the required grid capacity is a major barrier. Further work is needed to understand how float-furnace designs could be modified to accommodate higher electric input. Hybrid technology for float glass remains promising but not yet commercially ready for deployment, with timelines dependant on advances in furnace design, quality assurance and grid connection feasibility.

[35] Haush, "The Future of Green Hydrogen in the UK: Meeting Net-Zero Goals," accessed May 6, 2026, https://haush.co.uk/the-future-of-green-hydrogen-in-the-uk-meeting-net-zero-goals/.

Liquid biofuels have also demonstrated similarly strong performance in hybrid electric-boost furnaces, only requiring small burner and delivery system adjustments, making them especially suited for large-scale electric melting processes where smaller fully electric furnaces are not viable and where maintaining conventional thermal profile is essential.

4.2.3 Cold-Top Vertical Melting (CTVM)

In container glass, the primary fuel switching pathway for the use of gas fired furnaces are CTVMs. The technology is used predominantly in container glass, and some specialty glasses as well, where the melting process happens vertically, allowing a uniform blanket of batch materials at the furnace top which is melted and falls down along the furnace. In CTVMs, electrodes can be inserted vertically to allow an electric current to the melt. An insulated cover on top of the melt is created by the batch material, ensuring heat is not lost to the superstructure.[36]

CTVMs have reached TRL 9 and CRI 6[34] where production is at approximately 180 tpd. Several furnaces are operating reliably at this scale throughout Europe, such as in France and Germany, where electricity costs are lower and sub-sectors higher value products are sold, making this commercially viable. Studies suggest that 300tpd is technically possible and early development plants are expected to explore this upper limit. However, the achievable maximum capacity remains uncertain and will depend on further design optimisation and operational validation for glass wool. For container glass, the larger furnaces could be replaced by multiple electric furnaces as experts predict that we will see a 600 - 700 tpd electric furnace in the next decade.

A key constraint on 100% CTVM is limited redox control, which restricts the production of certain glass colours, particularly amber glass, where the required reducing conditions cannot be achieved in a fully electric environment. CTVMs also face limitations on the proportion and type of cullet that can be used, with challenges arising from coloured cullet and variable recycling feedback chemistry.

The capital expenditure of CTVMs is one that most firms are willing to invest in. CTVMs only last 7-9 years, compared to regenerative natural gas furnaces that can have a lifecycle from 12-20 years. However, they are more compact as they do not have regenerators, and therefore have a lower CapEx to replace.

However, operating expenditure remains a key concern. The costs of CTVMs are highly dependent on electricity pricing. Recent industrial support schemes have narrowed the gap between electricity and natural gas and improved the affordability of electric melting. Cold-top systems are inherently more energy efficient than gas-fired furnaces, but overall viability remains highly sensitive to fuel prices.

CTVMs benefit from strong efficiency characteristic - the CTVM furnace currently operating in France is very efficient and achieves a melting efficiency of <0.9 kWh/tonne melted.

Issues remain for CVTMs with high cullet, but furnace manufacturers have developed hot top electric melters to solve this issue.

[36] Department for Energy Security and Net Zero, Future Opportunities for Electrification to Decarbonise UK Industry: A Report for DESNZ (London: Department for Energy Security and Net Zero, 2024), https://assets.publishing.service.gov.uk/media/67295df0541e1dfbf71e8b50/future-opportunities-for-electrification-to-decarbonise-uk-industry.pdf.

4.3 Supply Chain: Raw Materials

4.3.1 Cullet

4.3.1.1 Combustion emissions savings from melting cullet

Melting cullet requires far less energy than melting raw materials and avoids process emissions released when carbonates decompose. Glass firms are already operating on 50-60% cullet[37] and see substantial reductions in fuel consumption and process emissions. British Glass estimates that every 10% of additional cullet will reduce carbon emissions by 5% and energy consumption by 3%[38]. However, higher cullet ratios alone cannot fully eliminate carbon emissions in this stage and various other measures such as the use of alternative raw materials such as granulated blast furnace slag (Calumite), may still be required to address remaining process emissions.

4.3.1.2 Waste and Recycling Issues

Firms aim to maximise cullet use as glass is infinitely recyclable and can be remelted without loss of quality, if cullet is clean and well-sorted. However, supply-chain factors influence availability and quality. Cullet availability is shaped by broader market dynamics. The UK imports green glass (mostly from wine and beer) and exports clear glass (notably spirit bottles), creating an imbalance in supply, with surplus green cullet and limited clear glass.

A substantial volume of recyclable glass is currently lost due to the current waste and recycling policy structure. An estimated 200,000-400,000 tonnes of cullet are diverted away from remelt annually, sent to landfills or exported internationally, as current Packaging Recovery Notes (PRN) policy financially incentivises material to be collected, shipped to ports and sold overseas rather than returned to UK manufacturing. PRN values can make it more financially attractive to export high-quality waste glass to the EU for reprocessing, as the UK exporter benefits from the PRN without having to invest in a UK reprocessing plant. The UK is effectively subsidising the removal of a valuable raw material, reducing domestic availability for remelt and increasing reliance on virgin raw materials.

Current recycling systems focus on quantitative measures (e.g. collection rates) without the necessary qualitative measures. This leads to large volumes of glass being mixed with other materials, reducing cullet quality and increasing losses within the recycling system.

The absence of a consistent, UK-wide kerbside collection scheme limits recovery efforts. Glass is most commonly collected in mixed-material collections, which, while convenient, requires sorting from the other packaging materials in a Material Recovery Facility (MRF). The glass output from the MRF has high-levels of non-target material, increasing process costs and reducing the volume of furnace-ready cullet[39].

Both central and devolved governments are progressing with Deposit Return Schemes (DRS) proposals. Firms warned that these schemes could reduce the volume of glass entering existing kerbside recycling systems and into parallel collection streams that are not integrated with remelt-focused processors. The risk applies across all sectors, but is especially significant for glass mineral wool producers, who rely on large consistent flow of post-consumer bottles.

Around 250,000 tonnes of flat glass from construction and demolition currently end up in aggregates or landfill rather than being recovered for remelt. Concerns were raised on the impact of landfill policy with glass classified as an inert material. The landfill tax structure can unintentionally make disposal a cheaper and more straightforward route than returning material to manufacture. Stakeholders felt that there are

[37] FEVE (European Container Glass Federation), Glass Packaging Circularity and Cullet (Brussels: FEVE, May 2026), https://feve.org/wp-content/uploads/2026/05/FEVE-position-Glass-packaging-circularity-and-cullet-May-2026.pdf.

[38] British Glass "Glass Sector Net Zero Strategy 2050." (2024) https://www.britglass.org.uk/sites/default/files/British%20Glass%20-%20Net%20Zero%20Strategy.pdf.

[39] J&B Recycling. (2024). Where does your glass recycling really go? Retrieved May 5, 2026, from https://www.jbrecycling.co.uk/jb-knowledge/where-does-your-glass-recycling-really-go

currently no meaningful incentives to encourage recycling in the construction industry, despite its significant role in generating recoverable glass waste. While parts of the glass sector are pioneering new recovery efforts and working closely with clients, progress remains voluntary and erratic.

Glass firms would welcome clarity on landfill tax reform as a phased approach, looking towards other European countries who have implemented progressive bans which allow companies and technology to be developed in advance and create a market. In 2025 a consultation for reform gave timelines that were far too ambitious and would not allow sufficient time for these industries to change.

Glass mineral wool manufacturers, who rely heavily on recycled container glass, warned that DRS and PRN changes could substantially reduce domestic supply of cullet. There is also long-term potential to recycle glass wool waste from demolition, and some firms have the technology to process this form of glass mineral wool waste to remelt and re-use and are also exploring alternate processes. As demolition activity grows, supportive policy could help develop the reprocessing technologies needed to prevent this material from being landfilled and eventually turn it into a viable secondary raw material. However, without clear regulatory or customer drivers, the economics of these systems are more difficult to square.

4.3.1.3 Cullet Requirements for CTVMs

Although most natural-gas fired furnaces can run very high levels of cullet (up to around 60%), increasing cullet levels past 75% presents issues for CTVMs. Currently, the clear glass sector struggles to reach 75% cullet due to cullet availability constraints, and this limit is not an immediate barrier. However, if the sector does aim to push cullet use higher in the future, this may become a real constraint for CTVMs.

This is one reason that hybrid furnaces using electricity and fuel may be a more practical option when using high levels of cullet. There are also potential ways to make higher-cullet melting more suitable for CTVMs, such as using alternative raw materials, but these options are at a very early stage and need further R&D to assess the feasibility of adapting batch formulations or raw-material blends to support higher cullet use in electric melting. An alternative approach is to use a hot top vertical melter.

4.3.1.4 Recycled Flat Glass in Float Production

The use of recycled flat glass in float glass production is constrained by strict quality and contamination standards. Even trace levels of certain metals, particularly nickel, pose a critical risk as they can form nickel-sulphide inclusions that are almost impossible to detect at first but may expand over time, creating stress points that lead to spontaneous breakage. The risk is especially problematic for large architectural panels, where failures are costly and often occur in clusters.

There remains a huge risk of contamination from handling equipment, especially stainless-steel contact surfaces that introduce nickel-chromium particles, as well as from demolition-derived material where dust, concrete fragments and stone are very difficult to separate from glass. Achieving higher recycled content in flat glass therefore requires tight control over handling and processing, ensuring that feedstock is free from metallic and mineral contaminants that compromise long-term product integrity.

4.3.2 Granulated Blast Furnace Slag (Calumite)

As previously mentioned, firms are also exploring alternative raw materials, such as specific grades of limestone with lower carbon such as biomass ash. Calumite is an established raw material widely used throughout the UK glass sector and is formally recognised as contributing to recycled content under the British Glass and the UK container manufacturers' methodology. It is a glassy by-product of iron production

that can be used to replace some carbonate-based raw materials in glass melting[40]. This reflects a broader industry interest in diversifying recycled inputs and strengthening supply chain resilience.

Calumite provides a range of operational and environmental benefits. Its glassy structure and chemical composition allows it to behave very similarly to cullet to support more stable operation and reduced energy and emissions. It also contributes to improved refining quality with fewer seeds and blisters and more consistent behaviour across production runs[41].

The key benefit of calumite is accelerated melting. Since it enters the furnace in glassy form and supplies key oxides directly to the melt, Calumite reduces the energy required to reach refining temperatures. This enables manufacturers to reduce energy consumption, lower furnace temperatures (particularly valuable when furnaces are older and refractories are weakened) and increase furnace flexibility as it is easier to reach higher temperatures when needed[42]. By reducing the number of chemical reactions required in the batch, Calumite helps to minimise chemical attacks on furnace refractories, helping extend furnace life.

In air-fired furnaces, NOx formation increases exponentially with temperature due to the nitrogen contained alongside oxygen in combustion air. As calumite enables melting at lower temperatures, it can significantly reduce thermal NOx formation. This is a practical route to NOx reduction in the glass sector without additional abatement equipment.

However, there are sub-sector specific limits to the use of calumite as it is important to note that the variability in composition is particularly challenging for flat and glass production.

4.4 Research and development for the Glass Sector

In the container glass sector, first-generation electric and hybrid furnaces are now an established technology and are operating in several countries. Although refractory wear can cause electric furnaces to have a shorter lifecycle than gas-fired furnaces, the next iteration of electric and hybrid electric-natural gas furnaces will likely look different as operators learn and refine designs. Most firms will have a guarantee on furnaces, usually for electric furnaces this is around 8 years and slightly longer for hybrid furnaces. Manufacturing of furnaces is continually improving, and stakeholders feel that the innovation for improving the lifecycle of the furnace falls on manufacturers to build a product that operates effectively and lasts.

Research with positive results is taking place in flat glass, and further research is needed on inserting higher electric input into furnaces for float glass, particularly given the large scale of these operations and the major barrier of securing required grid capacity.

In glass wool, electric melting and hydrogen firing were cited as areas where promising work is underway. However, fiberising and curing remain highly gas-intensive and require further innovation to deliver meaningful emissions reduction.

Although the focus for the glass sector is on primary decarbonisation pathways, methane pyrolysis technologies are also still in the early phases of development, although it is not being significantly considered by the sector as the priority remains on electrifying as much as possible and then supplementing this with hydrogen or biomethane.

In addition, alternative raw materials to carbonates present a key area of further research, with early evidence suggesting that biomass ashes offer a potential solution. Using alternative raw materials, other than cullet, is at an early stage of research and further work would be beneficial to determine if batch formulations or

[40] "Recycled Content of Glass Packaging | British Glass." (2019). Www.Britglass.Org.Uk. Accessed August 5, 2026. https://www.britglass.org.uk/knowledge-base/resources-and-publications/recycled-content-glass-packaging.

[41] Calumite. 2014. "Glass Quality - Hanson Calumite." Hanson Calumite. December 5, 2014. https://calumite.co.uk/the-product/benefits-of-calumite/glass-quality/.

[42] Calumite." 2014. "How Calumite Works - Hanson Calumite." December 5, 2014. https://calumite.co.uk/the-product/how-calumite-works/.

blends of raw materials can be adapted to support the use of higher cullet in electric melting. Targeted R&D is needed to understand how alternative raw material blends could be adapted for next generation electric furnaces. Calumite could also act as a bridge to eliminating process emissions on top of the work that has already been done on increasing cullet by reducing reliance on carbonate-based raw materials.

4.5 Glass Sector Policy Recommendations from Stakeholders

For the glass sector, the key consideration is that the limited funding and resources available should be directed to UK glass sites to support their decarbonisation, particularly in the primary pathways of electrification supplemented by hydrogen or biomethane. Without this funding, the UK will lose out on investment and furnaces which are due for rebuild could close.

4.5.1 Circular Economy Reforms

Strengthening opportunities for circularity within the glass sector is one of the most immediate policy levers available to government and should be used to **substantially increase cullet availability and quality**. Participants identified opportunities with a clear view that policy reform, particularly within the Department of Environment, Food and Rural Affairs (DEFRA), could unlock significant emissions reductions. This would require more joined-up thinking across government departments in relation to waste policy, local authority systems, and industry practice. The same measures could also aid other alternative raw materials originating from industrial by-products being used within the glass industry.

Reforming the PRN system and reclassifying glass waste to close the inert-landfill loophole would help **retain more cullet within the UK**. Firms felt that the UK has strong potential for a **cullet market as most glass waste could be used domestically**, with only a small portion of green glass likely to require export due to colour-mix constraints. Strengthening collection systems, improving sorting infrastructure and aligning incentives across the value chain were identified as key enablers. Supportive policy would enable the sector **to switch to low carbon fuels reduce, process emissions from raw materials** and build on past achievements, ensuring growth by **creating jobs and strengthening supply chains.**

Government departments should work in a coordinated way, particularly given the close links between recycling policy, cullet availability, and wider decarbonisation measures. Fragmented policy continues to create conflicting incentives, reinforcing the need for a coherent, cross-government approach spanning the Department for Business and Trade (DBT), DESNZ, DEFRA and The Treasury. A unified strategy would **provide stability and clarity required for long-term investment to help ensure that circular-economy reforms and industrial decarbonisation policies work together** for a shared purpose.

4.5.2 Support Innovation & Scale-Up: Follow-on funding for Net Zero Innovation Portfolio (NZIP)

The UK has built a strong foundation of innovation through programmes such as NZIP, creating a pipeline of technology developers. This early-stage investment has positioned the UK well, but with funding not being renewed, several promising projects which had planned to use NZIP funding has now stalled and not taken place. Firms developing low-carbon enabling technologies are increasingly looking to invest internationally. This risks the UK continually importing technologies it helped to develop, rather than scaling them domestically.

A structured follow-on funding mechanism could **allow the UK to build on the achievements of NZIP**. Many technologies are currently at TRL 9 such as hybrid furnaces for container glass and glass wool, and CTVMs.

Urgent follow-on support is needed for UK furnaces which are due for rebuild to electrify using existing commercially available technologies **to ensure investment in UK sites and prevent site closure**.

The UK may also lose the opportunity to commercialise its own technologies as supporting these technologies is **a key industrial opportunity to scale UK-based solutions to create jobs, strengthen supply chains, and position British companies to compete globally, ensuring that the economic benefits of innovation remain within the UK.**

Scale-up support must reflect the diversity of processes across the glass sector. For example, while facilities such as those at Glass Futures provide valuable capability for float and container glass, they are currently of only limited relevance to glass wool manufacturing due to differences in chemistry and absence of fiberising equipment.

Developing and trialling fiberising technology requires highly specialised infrastructure, large volumes of material, and involves significant operational cost. As these processes have limited information-sharing capabilities due to IP constraints, targeted support for dedicated facilities in individual firms (rather than shared facilities and approaches) is key to ensure commercial sensitivities are appropriately managed.

5. Ceramics Sector Deep Dive

Emissions from ceramics production arise from two key sources: the chemical transformation of raw materials during firing (process emissions), and fossil fuel combustion with the sector's long-standing reliance on natural gas, built on more than 80 years of experience with gas-fired kilns. In terms of total sector emissions, Ceramics UK's 'Decarbonising UK Ceramics Manufacturing' roadmap stated that in 2019:

- emissions from fuels from firing accounted for 61% of total sector emissions
- indirect emissions from electricity accounted for 11% of total sector emissions
- process emissions from the decomposition of carbonates in raw materials accounted for 28% of total sector emissions

Kilns represent one of the most technologically challenging parts of the ceramics production process to decarbonise. Firms cannot simply substitute a new energy source without impacting product quality and process stability. There is limited technical maturity of kilns operating effectively on hydrogen at the high temperatures required with techno-economic challenges of firing with electricity. Combustion-based systems allow for high-temperatures and natural turbulent flow. Re-creating these conditions in an electric system requires significant redesign and engineering innovation. Electric tunnel kilns are available only at small scale, and where they do exist, they lack the turbulence and convective flow that combustion naturally provides. A national demonstrator, capable of firing large batches in an electric tunnel kiln, may significantly accelerate innovation and reduce risk. However, others feel that production methods are too diverse for a national demonstrator and this would not significantly help.

The Ceramics UK roadmap shows carbon emissions close to 1.25 million tonnes in 2019. Although significant progress has already been made to reduce carbon emissions by 47% since 2003 to 2019, the long-term challenge is most present in process emissions where reductions reach a 68% reduction by 2050, compared to a 104% reduction in fuels for firing, through expansion of hydrogen, funding support for grid connections and access to bio-energy for certain site-specific applications[43].

The ceramics sector is recognised as one of the hardest foundation industries to decarbonise due to:

- 90% of ceramic production sites in the UK being classed as small or ultra-small emitters with larger installations accounting for a disproportionately high share of total sector emissions
- dispersed sites located close to raw materials (away from industrial clusters)
- diverse product types and manufacturing processes
- many firms remain reliant on traditional energy sources, primarily natural gas

Department for Business and Trade's 2025 Business Population Estimates shows the number of firms of various sizes in the glass and ceramics sector[44]:

[43] Ceramics UK, Decarbonising UK Ceramic Manufacturing Roadmap: Interactive PDF (Stoke-on-Trent: Ceramics UK, 2024),https://static1.squarespace.com/static/6566f758dd1a4c385d6b7a86/t/65b8d0ce61458d1b000a5963/1706610905794/Roadmap+Interactive+PDF.pdf.)

[44] Department for Business and Trade, Business Population Estimates for the UK and Regions 2025: Statistical Release, GOV.UK, published October 2, 2025, https://www.gov.uk/government/statistics/business-population-estimates-2025/business-population-estimates-for-the-uk-and-regions-2025-statistical-release.

Glass – Total 560

Size	Number of firms	% of total
Micro (1-9 employees)	310	55.4%
Small (10-49 employees)	165	29.5%
Medium (50 to 247 employees)	70	12.5%
Large (250+ employees)	15	2.7%

Total Ceramics – Total 435

Size	Number of firms	% of total
Micro (1-9 employees)	315	72.4%
Small (10-49 employees)	70	16.1%
Medium (50 to 247 employees)	35	8%
Large (250+ employees)	15	3.5%

Cement, Lime and Plaster – Total 10

Size	Number of firms	% of total
Micro (1-9 employees)	0	0%
Small (10-49 employees)	0	0%
Medium (50 to 247 employees)	10	100%
Large (250+ employees)	0	0%

Concrete, Cement and Plaster – Total 825

Size	Number of firms	% of total
Micro (1-9 employees)	480	58%
Small (10-49 employees)	260	32%
Medium (50 to 247 employees)	65	8%
Large (250+ employees)	20	2%

(Other) Chemicals – 425

Size	Number of firms	% of total
Micro (1-9 employees)	220	52%
Small (10-49 employees)	115	27%
Medium (50 to 247 employees)	80	19%
Large (250+ employees)	10	2%

Iron and steel and of ferro-alloys - 460

Size	Number of firms	% of total
Micro (1-9 employees)	295	64%
Small (10-49 employees)	110	24%
Medium (50 to 247 employees)	45	10%
Large (250+ employees)	10	2%

The ceramics sector pointed out the specific barriers which arise from the SME-dominated nature of the sector. Ceramics is made up of a many dispersed sites and SMEs which tend to have limited capital expenditure and resources to partake in R&D investments, expensive fuel-switching and ability to compile and compete for various government bids. Investing in low-carbon technologies and fuel switching requires tolerance for long payback periods with kilns that can last up to 50 years. For the ceramics sector, tight margins, limited capital and shorter investment return are key barriers, meaning even technically viable projects are prohibitively expensive to deploy.

Moreover, characteristics differ between ceramics and other energy-intensive sectors. For example:

- cement, steel and glass contain companies with varying emissions levels, including typically fewer but larger emitters, and sometimes co-located installations
- chemicals face issues with coordination as decarbonisation is dependent on shared cluster infrastructure and interdependent feedstocks
- food and drink have many SMEs but generally has lower temperature heating demands and strong buyer influence from retailers

In ceramics, the SME-dominance coincides with the sector also being highly energy-intensive/high-temperature processes, most sites being small and ultra-small emitters (with dilute carbon emissions) and a dispersed industrial base and process emissions from raw materials. The combination of factors creates a distinctive and persistent barrier to decarbonisation.

Rising costs have pushed several long-standing businesses to the brink, with firms increasingly undercut by international competitors. While the sector welcomes the increased government commitments to R&D and

clean energy investment, there remains an urgent need for targeted support for technology roll-out, hydrogen access, and protection against carbon leakage[45].

Ceramic manufacturers often deliver wider sustainability benefits through the performance of their products. For example, refractories that reduce energy use across heat-intensive industrial processes, including power generation and all heat-using industries. Better-performing refractories reduce energy losses in other energy-intensive industries' furnaces, meaning refractory R&D has a multiplier effect on national decarbonisation that is not well reflected in how refractories' own emissions are accounted for and in how sustainability impacts are assessed and recognised.

Despite these challenges, many firms have taken steps to reduce emissions and have invested in efficiency improvements, process optimisation and incremental technology upgrades such as heat recovery and kiln upgrades. Many have had to fund this work themselves without the level of government support available to other energy-intensive industries.

There are very different characteristics in production methods across the sector:

- The greatest challenge lies in heavy clay, whitewares, and some refractories production where high-volume, high-temperature firing is largely dependent on natural gas.

- A number of technical ceramics and other refractory producers are already electrified, typically produced in smaller volumes, and often manufactured in batch processes or small tunnel kilns.

There is no singular decarbonisation solution for the ceramics sector, and maintaining multiple pathways remains critical. Ongoing research is exploring biofuels, hydrogen firing and electric firing, while biomethane has already demonstrated effectiveness in comparable with high-temperature sectors such as glass.

5.1 Fuel Combustion Emissions

5.1.1. Drying Processes and Waste Heat Recovery

Whilst discussions often focus on decarbonising the firing process, stages such as product drying and spray drying for granulation, also consume significant energy.

Addressing these offers important opportunities for near-term emissions reduction. Many companies have already implemented measures such as redirecting airflow and optimising heat use such as installing full heat recovery systems which powers spray drying operations using heat recovered from furnaces. Many firms are actively pursuing these ‘low-hanging fruit’ opportunities, where proven technologies can be deployed with limited R&D requirements.

The drying process typically relies on low temperature heating and there is considerable scope to improve efficiency by revisiting both process design and associated emissions (albeit these may be small).

A significant portion of gas consumption also currently goes into dryers where large volumes of moisture are driven off. Much of the energy used in this stage is lost through exhaust streams, yet this moisture and low temperature heat could be recovered as a water source to a heat pump to supply higher temperature heat to the drying process, switching from gas heating to electric heating, improving both energy efficiency and water resource efficiency.

Measures such as heat recovery can be implemented without fundamentally altering product performance. Beyond reducing energy usage, such measures can also lower water consumption. Interim improvements in drying efficiency can meaningfully reduce carbon emissions. Batch kilns were identified as a particularly

[45] IOM3. 2020. “Keeping the Kilns Burning.” Iom3.org. 2020. https://www.iom3.org/resource/keeping-the-kilns-burning.html.

high-potential area for heat recovery, with estimates suggesting that up to 90% of heat generated may be recoverable (where this is applicable).

5.1.2. Hydrogen

For many in the sector, hydrogen is widely regarded as the most viable long-term alternative to natural gas for high-temperature firing. Hydrogen firing is currently at TRL 7 following phase 2 of the Demonstrating Hydrogen in the Ceramics Sector' project[46], and is rapidly progressing towards TRL 8, building on the success of the project. For specific subsectors, such as heavy clay, electrification is not currently a viable option and support on other pathways such as hydrogen will be required. Larger manufacturers, particularly those in heavy clay and refractories see hydrogen as the most credible option as their processes cannot be readily electrified at scale. Existing kilns could also potentially be converted for hydrogen use rather than fully replaced. Burner systems must be redesigned but the kiln structure can remain largely intact. Despite substantial investment required, hydrogen conversion is a lower-CapEx route than for electrification which requires full kiln replacement, extended factory downtime, significant capital expenditure and grid reinforcement.

As discussed above, the appeal of hydrogen lies in its ability to replicate the combustion characteristics of natural gas. Gas firing provides radiant heat, internal turbulence, convection flow, and uniform heat distribution which are essential for firing large, dense products such as bricks and refractories. Air distribution and turbulence is needed to heat the product uniformly, which is only possible through combustion. For example, for refractories specifically, product density and the need for uniform heating through thick cross-sections (unlike thinner-walled ceramics) make this turbulence/convection requirement even more critical, meaning refractories may need bespoke burner and kiln redesign work beyond what's developed for other ceramic sub-sectors.

However, hydrogen remains significantly more expensive than natural gas as a fuel, and without sustained government support the economics of fuel-switching will continue to be prohibitively expensive for most ceramic manufacturers. Access to hydrogen infrastructure is also a major limiting factor. While some regions may benefit from planned hydrogen hubs, most ceramic facilities are geographically dispersed and unlikely to receive early network connections.

Hydrogen firing equipment is still at an early stage of development and there is limited availability of commercial hydrogen burners and an absence of proven large-scale hydrogen kilns. Burner manufacturers have limited experience producing hydrogen-compatible systems for kilns. Given this, there is also a lack of established supply chains for such equipment. Firms involved in early trials described working closely with suppliers to co-develop prototype burners highlighting a need for multi-fuel flexibility.

Recent work with the ceramics sector has focused primarily on hydrogen fuel switching, including DESNZ-funded research and the installation of a 2-tonne-per-day hydrogen pilot kiln. Across a wide range of ceramic products, firing on hydrogen blends up to 100% has delivered product quality which is broadly similar to natural gas, with no major deviations reported in initial results[47].

A key unresolved issue relates to colour-dependant firing requirements. Many brick colours rely on a controlled reducing atmosphere, created by managing the oxygen balance relative to the fuel. Achieving these conditions with hydrogen is uncertain and may require changes to additives, firing cycles or kiln atmosphere control. Colour, surface finish, and material behaviour all need to be validated for each product line from pilot to full-scale production.

[46] Ceramics UK. Ceramics UK Reaches Key Milestone in Hydrogen Project. Available at: https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project. Accessed 15 September 2026.

[47] Ceramics UK. Ceramics UK Reaches Key Milestone in Hydrogen Project. Available at: https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project. Accessed 15 September 2026.

Projects such as hydrogen-fired kilns likely remain several years from full operation and it is not clear yet what testing will be required or if the production of certain products may revert temporarily to natural gas for colour-critical runs. Overall, hydrogen firing appears technically feasible for many ceramic products, but colour-sensitive bricks remain an area requiring further R&D, time and investment.

For the ceramics sector, NOx emissions are a key concern when considering fuel-switching, particularly to hydrogen. As discussed above, hydrogen combustion can significantly increase thermal NOx emissions and abatement may be required, but this would introduce significant additional capital and operating costs. For many firms, particularly SMEs, these costs could undermine the business case for hydrogen entirely.

NOx and trace contamination in biomethane could also affect product quality or become trapped in ceramics materials, reinforcing the need for robust technical research and clear regulatory guidance before alternative fuels are adopted at scale.

5.1.3 Electrification

Electrification offers meaningful opportunities in drying and selected low-temperature processes, but for most ceramics manufacturers it remains a long-term possibility rather than a near-term pathway, as flame-based firing in gas kilns is integral to achieving specific product characteristics.

Electrified kilns would require far more power than many local grids can currently supply (or are currently being planned for) and so requires new or significantly reinforced electricity connections at distribution level, and sometimes the transmission level. Most kilns are currently firing gas at a rate of 5 to 10 MW per hour. Whilst replacing this with electricity would be more energy efficient, this could require increases in power supplies to sites above 5 MW electric. Currently, large heavy clay sites have a 1 to 2 MW electrical supply.

Electrification is not currently a viable option for large-scale kiln decarbonisation as it is technically uncertain and requires costly kiln replacement and site downtime. Gas kiln combustion produces hot gasses which have momentum for burners, creating a strong convection and mixing which help to create uniform heating of a large volume of air. However, electric kilns rely on heating elements which heat the air proximal to the element and do not create the same flow of air that burners do. This means there is less mixing and buoyancy driven convection from the heating around an element, leading to hot spots near the element and colder zones in the middle of the kiln, meaning temperature uniformity is more challenging in electric kilns. Despite this, there are a number of electrified kilns already in use in the sector, for smaller-scale, product-specific and R&D applications

For example, one company is currently electrifying production by replacing a gas-fired factory with a new electric facility. However, this is only possible because; the process operates at a lower temperature, the product mass is smaller, and a new factory is being built rather than retrofitting an existing kiln. Even in this case, significant obstacles remain with high capital cost of full equipment replacement, limited availability of electric kiln technology at industrial scale and insufficient local power capacity.

For many products there is currently no commercially or technically viable electric kilns at sufficient scale to be used for mass production, such as brickworks, or refractories which rely on sintering at extremely high temperatures in mostly large batch kilns. This is not simply a technology-maturity gap but also a scientific and technical gap: sintering at the extreme temperatures which refractories require is fundamentally harder to achieve electrically than the firing temperatures used for other ceramic products, meaning refractories should not be expected to follow the same electrification timeline as lighter-duty ceramics.

Even if large-scale electrified kilns eventually become technically possible, and viable (by operating costs) adopting them would require complete kiln replacement, which would be extremely costly and disruptive.

Some firms suggested that whilst larger kilns cannot be electrified, smaller units could be used for small production lines, specialist materials, partial production shifts and pilot-scale firing. Parkinson-Spencer Refractories estimated that shifting even 20% production to smaller electric kilns could meaningfully reduce emissions. This would require access to specialised kiln manufacturers, capital support, technical

collaboration, and redesign of production flow. However, this would have wider consequences and is product-dependant, not a widespread solution. This could support early adoption of lower-carbon technologies whilst allowing manufacturers to experiment with new production materials. It should be noted that refractories are more constrained here than other ceramics, since sizes and shapes are often large and set by the customer's furnace specifications (e.g. steel or glass furnace linings). This limits electrification to smaller or specialist product lines, without affecting core production.

Moreover, some stakeholders highlighted that efficiency of large-scale production is intrinsically tied to continuously operating kilns, and so whilst smaller intermittent processes may offer some advantages, these may be outweighed by efficiency losses elsewhere (particularly as batch kilns involve a complete temperature cycle from ambient temp, to peak firing, back down to ambient). From this perspective, moving from large kilns to multiple smaller units may undermine production economics and other energy and environmental regulatory obligations for businesses.

Dryers present a more realistic near-term opportunity for electrification than kilns. Many sites already recover heat from kilns into dryers, requiring only a small gas “top-up”, and some firms operate additional sand dryers that could potentially switch to alternative fuels. Beyond this, some companies procuring renewable energy through REGOs or investing directly in on-site solar generation.

However, switching of a gas-fired dryer to electric operation would require extended site downtime and can be technically complex as well as disruptive. In many cases, switching to a different fuel, such as hydrogen, may be less intrusive than full electrification.

Technical ceramics offer some insight into what partial electrification can achieve, where small tunnel kilns and batch processes are often electrified in parts of that sub-sector, but these examples operate at much smaller volumes and lower thermal loads. For higher-volume materials such as clay bricks, refractories and whitewares, electricity remains impractical due to heat transfer limitations and the absence of suitable industrial-scale technology. It should be acknowledged that technical ceramics operate at much smaller volumes and lower thermal loads, so this isn't a directly comparable precedent for high-volume production.

5.1.4 Process Emissions

The ceramics sector is uniquely challenging to decarbonise, given that a substantial proportion (28%) of emissions from ceramics manufacturing comes from the inherent chemistry of clay-based and mineral-based materials[48]. When fired, carbon-containing compounds within the raw materials (and some ancillary process steps e.g. fluoride scrubbers) release carbon emissions. These process emissions cannot be addressed through equipment change and have no technological solution at present. Any credible pathway to decarbonise the sector must therefore consider material substitution, product adaptation, alternative formulations, enhanced recycling, and long-term innovation in raw materials processing.

5.2 Supply Chains

The current supply chain environment creates a weak commercial incentive for manufacturers to invest in low-carbon technologies.

Upstream, a number of ceramic producers in certain product groups are heavily reliant on imported raw materials, creating exposure to embodied emissions and supply risks which vary by sub-sector. Although imported raw materials are used across all sub-sectors, the quantities differ throughout the sector.

[48] Ceramics UK, Decarbonising UK Ceramic Manufacturing Roadmap: Interactive PDF (Stoke-on-Trent: Ceramics UK, 2024),https://static1.squarespace.com/static/6566f758dd1a4c385d6b7a86/t/65b8d0ce61458d1b000a5963/1706610905794/Roadmap+Interactive+PDF.pdf.)

Refractories and technical ceramics are particularly concerned about upstream embodied emissions in imported feedstocks, whereas traditional whitewares benefit from a strong domestic supply chain with china clay sourced from quarries in Devon and Cornwall.

Downstream, firms face a market that is highly price-sensitive as consumers are generally unwilling to pay more for low-carbon products. This combination makes it very difficult for firms to make up the additional cost of decarbonisation. This is particularly challenging for SMEs that have limited capacity to absorb additional costs or undertake major R&D programmes.

Across most of the sector, there is little evidence of a meaningful market for decarbonised products as customers are generally unwilling to pay a premium for lower-carbon products. Whilst there is growing interest in sustainability, this has not yet been translated into a willingness to absorb higher costs associated with lower-carbon products except in certain sub-sectors.

In technical ceramics, products are typically small components within complex systems such as MRI scanners and industrial pumps. Stakeholders outlined that customers rarely request “green variants” of these components and are unwilling to pay a premium for these small components as they are a marginal carbon savings in a component with a negligible impact on the overall product footprint.

This lack of market pull is a major barrier to investment as with no clear route to market, innovations struggle to progress beyond pilot scale. Policy interventions such as requiring low-carbon choices, may eventually be needed to stimulate demand.

There are other facets to which decision-making is made. UK ceramic goods are often recognised internationally for being of inherent high quality, and producers have been able to compete on this basis, rather than solely on price. However, this differs to the mass market where overseas producers have been seen to significantly undercut domestic production in the UK.

Companies are actively exploring product adaptation, such as brick slips and thin bricks, to reduce material use, energy use and associated emissions whilst still offering the merits and aesthetics of the product. Such innovative products may offer sustainability benefits yet there needs to be greater market “pull” and demand for companies to justify further significant investments in bespoke manufacturing facilities. They may also fall outside existing research that feeds into traditional standards and specifications. These challenges relate not only to formal, published standards but also to informal industry norms and expectations, which can limit the adoption of new or more sustainable product designs.

5.2.1 Raw Material Dependencies and Upstream Supply Chain Risks

Some facets of the sector (like technical ceramics and refractories) also heavily rely on imported raw materials processed internationally, with limited domestic supply or processing capacity. It should be noted however these account for limited tonnage output of the overall ceramics sector. In such circumstances, UK ceramics producers have limited influence over upstream emissions embedded in their raw materials, and few opportunities to shape how these materials are processed before they reach the UK. As a result, environmental standards vary across suppliers, supply chains are vulnerable to disruption and cost volatility and opportunities for low-carbon material substitution are constrained. For example, most specialist refractory raw materials are mined and processed overseas where the processing itself is often energy-intensive (e.g. fused/sintered alumina), with very limited UK domestic capacity.

This dependency also limits the ability to reduce embedded emissions in raw materials for some companies, which can form a relatively significant share of total product emissions, this links raw material sourcing directly back to the Scope 3 emissions challenge for the sector.

5.3 Regulatory Issues for the Ceramics Sector

5.3.1 Product Innovation and Alternative Product Use

Innovation and product design is becoming increasingly prevalent in the ceramics sector, given the demanding product performance and niche applications for all certain products as well as the challenge of addressing process emissions. Firms are actively exploring product adaptation, such as brick slips and thin bricks, to reduce material use, energy use and associated emissions whilst still offering the merits and aesthetics of the product. Such innovative products may offer sustainability benefits yet there needs to be greater market "pull" and demand for companies to justify further significant investments in bespoke manufacturing facilities.

Product innovation is often constrained by the cost and timeframes of testing for traditional standards and specifications, together with overly prescriptive expectations that tests are repeated for every new product variant. A demonstrative example is dematerialisation for bricks, through via thinner formats (thin bricks and brick slips) or higher perforation levels which runs into rigid test thresholds and stringent performance criteria for fire resistance, rain penetration, strength and durability. As removing more clay increases the risk of failing these tests, manufacturers typically adopt a pragmatic approach of testing only the most concerning variants (e.g., the highest-perforation bricks). However, with thousands of brick types in the market and only a few accredited test houses, full coverage is prohibitively expensive and time-consuming, deterring investment in more sustainable designs.

5.3.2 Eligibility for Government support on energy costs

The UK Ceramics sector faces significant barriers in accessing government's energy cost support schemes due to a number of contributory factors, largely around the accuracy and non-reflectiveness of data used in eligibility assessments.

Some stakeholders discussed existing support measures, such as the Supercharger Scheme, which in its current design, offer no relief to firms whose primary energy source is gas, and felt that for energy-intensive firms that rely on natural gas to fire their kilns, meaningful support scheme must address natural gas consumption directly as energy costs represent a significant overhead.

Although ceramics is largely recognised for its heavy reliance on natural gas in key production processes, the primary energy source of both the sector and individual companies hold no relationship to its electro-intensity. Indeed most (but not all) ceramic product SIC codes are currently recognised as being electro-intensive[49]. As a result, the overall gas-intensive nature of ceramics production has often led to misunderstandings in the sector's advocacy (given that support measures are largely available through electricity costs). The industry's concerns are often overlooked, such as why certain product groups should be eligible. One stakeholder described the additional UK 'business-level' test, that has to be passed, as being potentially unrepresentative with distortive effects'. Further details on the quality of government data used to determine eligibility for government energy cost support schemes are outlined below.

Beyond targeted support schemes, government must also address the structural disparity in UK energy pricing: UK manufacturers face energy costs approximately four times those of their US counterparts and roughly twice the European average, presenting a significant competitive disadvantage.

[49] UK Department for Energy Security and Net Zero, Energy Intensive Industries: Guidance for Applicants Seeking a Certificate for an Exemption from the Indirect Costs of Funding Contracts for Difference, the Renewables Obligation, the Small-Scale Feed-in Tariff, and GB Capacity Market (London: UK Government, 2025),https://assets.publishing.service.gov.uk/media/69fc5886cd2e0e8b5b20b21e/energy-intensive-industries-certificate-for-exemption-funding-contracts-for-difference-renewables-obligation-feed-in-tariff.pdf.

5.3.2.1 Quality of Government Data

Eligibility for schemes such as the Energy-Intensive Industries (EEI) British Industry Supercharger Scheme and Energy-intensive Industries Compensation Scheme is firstly determined at a product/SIC level using sectoral electricity-intensity and trade intensity tests, both of which rely on government datasets that are inherently linked to businesses at Companies House. Periodic surveys by the Office for National Statistics map business data by their Standard Industrial Classification codes (to describe business activities) which companies self-select but with no checks or verification of their appropriateness. Ultimately, far more companies are using the SIC code associated with manufacturing of ceramics, compared to the number of businesses that are UK-based ceramics manufacturers; which inflates these datasets and therefore, are non-reflective of the structure and performance of the UK Ceramics sector. For example, SIC 2332 is the code used for Manufacture of Baked Clay Construction products. This is supposed to capture and reflect the companies in the UK that manufacture baked clay construction products such as clay bricks, clay roof tiles and clay drainage pipes. However, the vast majority of the companies registered under SIC 2332 are using this code inappropriately; particularly linked to product sales (merchants, importers and distributors) and downstream use (brick-layers, builders etc.), and with many other unrelated businesses. This greatly distorts the data as only 10% of registered companies are genuine manufacturers of baked clay construction products. This inflates government data in areas such as sector turnover figures and gross value added (GVA), which impacts (lowers) the apparent energy intensity of a product SIC. It is essential to note here that although the example of SIC code 2332 for baked clay construction is given, this problem applies across all ceramics sector SIC codes. For example, refractories (SIC code 23200) is equally affected and faces almost identical data-accuracy issues, and sectors such as tableware (2341) and sanitaryware (2342) are deemed ineligible such schemes.

5.3.2.2 The use of GVA in Eligibility Assessments and Standardisation of Reference Prices for Energy

With electricity-intensity tests utilising a GVA-based approach, the inclusion of staff costs in GVA calculations (which are higher in labour-intensive companies like in the ceramics sector, and can account for up to 75-80% of total GVA) distorts the electro-intensity results and makes it much harder for businesses in the sector to qualify for support. For example, it is again the most labour-intensive sectors such as tableware (2341) and sanitaryware (2342) which are ineligible for the British Industry Supercharger scheme. 'Average' industrial reference prices are also used in tests, although smaller electricity consumers (like ceramic producers) pay more than this. This also downplays their apparent electro-intensity.

International competitiveness is shaped by energy costs, and support schemes are therefore critical to the sector's ability to survive and compete. Government should undertake a holistic review into the standard eligibility mechanisms it uses in the majority of energy support schemes for industry. Without such action, future policy reform risks continuing to misrepresent the sector, undermining competitiveness and hindering its pathway to electrification. The ceramics sector's energy-intensity (both for electricity and gas) should be more accurately reflected in government's understanding of the sector, and available support in order for firms to survive, compete internationally and plan for fuel-switching. Although stakeholders had differing views across the sectors, some felt that energy costs for gas-intensive sectors should also be considered for support schemes. Reviewing the UK government's approach to eligibility for support on energy costs is critical to ensure the sector has access to cost-relief schemes. This may help firms to more-realistically plan for electrification as a pathway and improve competitiveness by reducing costs.

5.3.3 Limitations of Mirroring EU Regulatory Approaches

Firms emphasised the need for careful scrutiny before adopting EU-driven standards or emissions benchmarks. Regulatory decisions must account for the UK's distinct production methods, differences in certain product designs, raw material characteristics and industrial structure to avoid unintended compliance burdens.

This issue is already emerging in the ongoing review of UK Best-Available Techniques for ceramics production already emerging in the ongoing review of industrial emissions regulations. The Environment Agency has indicated that where UK evidence is limited, it may default to adopting European-derived Associated Emission Levels. However, UK manufacturers face different raw material profiles, including clays with naturally high sulphur content, and produce certain niche products using methods not common elsewhere in Europe. Legacy permitting frameworks also differ, meaning that direct alignment risks imposing requirements that do not reflect UK production realities.

5.4 Research and Development for the Ceramics Sector

Although several proven technologies exist for the decarbonisation of ceramics products, R&D is still required to address the more complicated aspects of decarbonisation for the sector. For the majority of ceramics production which remains dependant on high-temperature gas firing and larger-scale kiln operations, substantial R&D is still required to develop solutions viable on a commercial scale. Targeted academic collaboration could help to address other key technical challenges for the sector, particularly in the areas of product adaptation and material substitution, alternative materials, kiln design, advanced heat recovery and disruptive carbon capture technology solutions to enable assets to continue to burn gas, whilst recovering 30% carbon emissions inherent in the material.

There is a need in the sector for strengthened collaboration with academia, greater awareness and engagement from industry, combined with a more targeted, sustained commitment from academic institutions to support ceramics innovation, in areas identified in the Ceramics UK sector Roadmap. Much of the R&D that has been progressed in the past, or is currently being progressed, has not necessarily been targeted in the areas that would deliver significant, tangible emissions reduction and may be of limited relevance to larger-scale standard ceramics production. Instead, R&D has often focused on product improvements aimed at downstream performance characteristics, niche areas and advanced product groups, whereas R&D into energy and emissions reduction is relatively limited.

Stakeholders emphasised that, in terms of decarbonisation, academia must be better aligned with industry needs for effective collaboration. The Ceramics sector has largely been an outlier, as other energy-intensive industries such as steel and cement, have been highly successful in leveraging academic expertise and securing large-scale research funding. It is worth noting that larger sectors such as steel and cement naturally attract more funding, given their higher emissions and the presence of fewer but much larger companies with greater capacity for resources and engagement. This also influences the level of funding committed to ceramics research, where emissions sources are more complex, overall volumes are smaller, and the importance and benefits of the product in its demanding applications and uses (rather than production) have driven research. Some stakeholders also noted that these challenges may not be unique to the UK.

A majority of the R&D already taking place in the sector is funded and progressed directly by firms themselves due to administrative burdens and complexities of government funding processes, particularly for SMEs.

There is significant potential for R&D through partnership with universities and research bodies. While funding routes such as EPSRC programmes, Innovate UK, and Knowledge Transfer Partnerships (KTPs) offer some potentially relevant opportunities, uptake across the ceramics sector has been shaped by more practical barriers associated with accessing these schemes.

5.4.1 Digital Twins

One suggested area is the development of digital twins for the ceramics manufacturing process. This type of digital modelling would allow manufacturers to test concepts virtually, such as substituting methane with hydrogen or comparing the thermal characteristics of electricity compared to combustion flames. A tool such as this would enable companies to explore process changes, assess and optimise designs before committing to major capital investment. Some manufacturers have already developed a full digital twin or a roller kiln, allowing them to modify and test a range of parameters virtually. The workshop highlighted strong industry interest in expanding these capabilities, but doing so requires sustained investment, collaboration and support.

Digital twins also offer a route to de-risking innovation for SMEs, many of whom lack in-house modelling expertise. By enabling virtual experimentation, companies can explore technical feasibility before committing to costly physical prototypes. Expertise from other sectors, such as steel, where digital furnace modelling is more advanced, could be brought into ceramics to accelerate progress.

5.5 Ceramics Sector Policy Recommendations from Stakeholders

The right enabling and supportive policies for the ceramics sector would **allow ceramics firms to access key energy support and level the playing field, mostly in terms of costs, between ceramics firms and other energy-intensive industries.** Academic collaboration also presents a key opportunity to **overcome the technical challenges** of decarbonisation for ceramics, particularly those related to hydrogen firing.

5.5.1 SIC codes

The SIC code challenge is uniquely difficult to fix as codes are self-selected by companies at registration, with no verification or oversight. Given the diversity of the ceramics sector and its high proportion of SMEs, even small inaccuracies have disproportionately large impacts.

Ceramics UK is calling for a more pragmatic approach. The sector is urging government to use trade association data directly when assessing eligibility for energy support, carbon leakage risk, and sector-level intensity calculations. Ceramics UK is currently undertaking a major data collection exercise to provide accurate company level information for the Supercharger Scheme and related assessments. Stakeholders emphasised this data is robust, sector-specific and far more representative than the distorted SIC-based datasets currently used.

SIC misclassification is a structural barrier that prevents energy-intensive ceramics manufacturers from accessing the support they need to remain competitive. Without recognition that SIC-based data is not fit for purpose for small, diverse, energy-intensive sectors like ceramics, the UK risks undermining its own decarbonisation ambitions and placing domestic manufacturers at a disadvantage relative to their European competitors.

This is a key opportunity as accurate, sector-verified data would **allow ceramics firms access to energy cost relief and protections against carbon leakage**, **removing a major structural barrier and strengthening the UK's competitiveness against imports.**

5.5.2. Strengthening Academic Collaboration

There is potential for relevant research and development through partnership with universities and research bodies focused on the sector's highest-impact decarbonisation challenges. There is a need in the sector for

strengthened collaboration with academia, combined with a more targeted, sustained commitment from academic institutions to support relevant ceramics innovation, not just in more advanced products like technical ceramics and refractories. Technical ceramics tends to attract more funding, despite representing only a small share of total sector emissions.

Academic collaboration should prioritise areas with no clear commercial pathway, hydrogen has a clearer development trajectory (with active pilots and demonstrators) and electrification remains technically and economically prohibitive for many larger sites. However, there is no clear pathway to decarbonise process emissions which account for almost a third of sector emissions and arise from firing raw materials. CCUS technologies are also not yet suited to the sector which is made up of smaller, dilute emissions and dispersed sites. Research, development and demonstration must target viable capture concepts for these conditions.

Academic collaboration could also **address key technical challenges for the sector including alternative low-carbon materials, kiln design for fuel switching, and heat-recovery technologies.**

Sustained, industry-led academic and research partnerships would be key to **unlock and de-risk innovation** across **traditional ceramics.** Finding a route towards decarbonising **process emissions** would be **incredibly impactful,** given that almost a third of process emissions in the sector comes from this and currently lack a clear, scalable abatement pathway.

6. Conclusions and Further Research

This report strengthens the evidence base for cross-cutting and sector specific decarbonisation techno-economic challenges and opportunities for the UK **glass** and **ceramics** sectors. Drawing on existing literature and targeted industry engagement, this report sets out clear policy recommendations to accelerate deployment of viable technologies and support areas of further research where solutions are not yet commercially viable.

Glass is comparatively closer to being able to decarbonise, with deployment now largely dependent on addressing cost, timing and investment risk. **Ceramics** face far more structural challenges as many processes have no like-for-like low-carbon alternative, high-temperature firing requires major kiln redesign, more disparate and distributed sites, process emissions with limited access to capital and limited support on energy costs.

The **glass** and **ceramics** sectors face a shared set of structural barriers that shape the feasibility and pace of decarbonisation. All credible pathways require significant and sustained investment, yet both sectors operate with long-lived assets, meaning decisions made at each rebuild cycle lock in technology changes for decades. High capital costs, uncertainty over future fuel availability, and the risk of stranded assets, make firms reluctant to commit without clear, long-term policy goals. High UK energy and carbon costs, combined with regulatory burdens and slow grid or hydrogen infrastructure development, weaken the UK's competitiveness and deter investment.

International competition remains a defining constraint for **both sectors**. UK firms are increasingly undercut by lower-priced imports produced in regions with lower energy costs, less climate drivers and more government support. Firms risk losing market share to overseas competitors, reinforcing the risk of carbon, jobs and investment leakage. At the same time, competition from alternative materials in sectors like construction and packaging, is increasing, as weight-based PRNs favour lighter, less sustainable options. Without action to even the playing field, combined pressures will continue to weaken competitiveness and incentives to decarbonise.

Across **both sectors,** addressing the underlying economics of energy is key. Firms cannot absorb the higher operational costs associated with fuel-switching or efficiency upgrade without targeted support. Decarbonisation also depends on stable, predictable, long-term policy clarity, while operational support is required to manage rising electricity and carbon costs. A zero-rating for biomethane could enable firms to use biomethane as the simplest, most practical short-term decarbonisation. OpEx and CapEx support, as well as a CfB mechanism is needed to allow firms to compete and thrive against rising international competition, especially in the absence of a significant reduction in electricity costs.

For **glass**, the focus of available funding should be on deploying electrification technologies, supplemented by hydrogen or biomethane. For **ceramics**, corrected SIC-based eligibility is essential and stronger academic partnerships to unlock energy support and accelerate technical innovation in traditional ceramics, particularly for process emissions.

International alignment is also key: any UK CBAM must be coordinated with the EU for the **glass** sector and based on robust UK-specific data for the **glass** sector to avoid undermining domestic competitiveness. Mechanisms such as output-based CfDs could provide powerful incentives by directly rewarding verified emissions reductions

Firms are approaching critical investment points for the next lifecycle of furnaces and kilns, yet many cannot commit without clarity on future energy costs, infrastructure and policy direction. The UK risks accelerated loss of industrial capacity, job losses in regions heavily dependent on these sectors, and further erosion of domestic supply chains.

With targeted and stable policy support, both sectors can become more competitive, innovative and resilient. Clear long-term signals would unlock investment in proven technologies for **glass** and support the R&D needed to tackle the most complex challenges in **ceramics**. Strengthening circularity, improving

energy economics and supporting deployment-ready technologies would protect skilled jobs, reinforce regional economies and secure critical supply chains. More broadly, enabling these sectors to decarbonise can better position the UK to lead in low-carbon materials and enhance industrial resilience.

Across both the **glass** and **ceramics** sector, the industry engagement has a shared set of R&D priorities, as summarised below.

Across **both sectors**, stronger academic partnerships are needed to deliver targeted, coordinated research that addresses core, broad decarbonisation barriers such as high-temperature firing in traditional ceramics, rather than niche or downstream product improvements. While funding routes such as EPSRC programmes, Innovate UK, and Knowledge Transfer Partnerships offer some potentially relevant opportunities, uptake is often limited by administrative burdens and misalignment with what research is needed for large-scale production. A sustained, strengthened commitment is needed from universities and research bodies to support simpler access to collaboration and help de-risk investment, accelerate demonstration and close the remaining technical gaps in both sectors.

In **glass**, although the predominant focus should be on accelerating the deployment of proven technologies, there are a few areas in which research could meaningfully support emissions reductions. Current research is underway on alternative raw materials to carbonates, with positive early evidence for biomass ashes as a potential solution and using higher cullet to reduce emissions. Further research, development and demonstration is needed to support the use of alternative raw materials other than cullet to adapt batch formulations and raw-material blends for next-generation electric furnaces and evaluate options, such as calumite, to reduce reliance on carbon-based inputs. In **flat glass**, further research is needed on inserting higher electric input into furnaces, although large-scale operations face grid-capacity barriers that need focused research and demonstration. In **glass wool**, fiberising and curing remains highly gas-intensive without a proven low-carbon alternative, meaning innovation is needed to achieve meaningful emissions reductions but with particular attention to each firm's own IP. Methane pyrolysis is also at an early stage and is not currently a sector priority.

In **ceramics** , much of the R&D that has taken place has focused on downstream performance and **advanced and technical ceramics,** rather than energy and emissions reduction for wider, large-scale production. Advancing targeted research and collaboration on kiln design and alternative raw materials is therefore a priority, particularly for SMEs that currently self-fund a lot of their own research projects due to complex government funding processes. Key R&D gaps remain in large-scale, high-temperature kiln operations. However, the sector has advanced hydrogen fuel-switching research, including a DESNZ-funded project and a 2tpd hydrogen pilot kiln, with phase 1 completed and phase 2 ongoing[50] and initial results show product quality broadly comparable to natural gas across blends up to 100% hydrogen. Research could also deliver meaningful emission reductions in product adaption, advanced burners, digital twins to de-risk investment. Commercially viable CCUS for smaller and dilute emissions streams and disruptive CCS technologies that could allow continued gas use while recovering the around 30% of process emissions inherent in raw materials are also key areas of research that could deliver substantial emissions research. Concerns over NOx and trace contamination in biomethane also underscore the need for robust technical research and clear regulatory guidance before wider adoption.

[50] Ceramics UK, "Ceramics UK Reaches Key Milestone in Hydrogen Project," accessed June 29, 2026, https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project.

Bibliography

Argus Media, “Q&A: UK’s Biomethane RGGO Auction to Add Transparency,” Argus Media, accessed September 16, 2026, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2652627-q-a-uk-s-biomethane-rggo-auction-to-add-transparency.

AIS Glass. “Flat Glass vs Float Glass: Key Differences, Features & Uses Explained.” Accessed June 29, 2026. https://www.aisglass.com/blog/flat-glass-vs-float-glass-understanding-the-difference/.

Anas Majdouli, “The Challenges of Capturing CO_2 from Low-Concentration Emissions,” Atoco, accessed September 11, 2026, https://atoco.com/blogs/the-challenges-of-capturing-co%E2%82%82-from-low-concentration-emissions/.

“Ardagh Group S.A..” 2023. Ardagh Group S.A. May 23, 2023. https://www.ardaghgroup.com/corporate/news-centre/detail/18705/Ardagh+Glass+Packaging+builds+breakthrough+%E2%80%98NextGen+Furnace%E2%80%99+in+Germany.

“Biofuels basics.” 2025. Jord.One. https://www.jord.one/blogs/biofuels-basics-exploring-solid-liquid-and-gaseous-biofuels.

British Ceramic Confederation. Hydrogen for the Ceramics Sector: Industrial Fuel Switching (IFS) Feasibility Report. United Kingdom: British Ceramic Confederation, 2023. https://assets.publishing.service.gov.uk/media/649aa7eede86820013bc8e8f/British_Ceramic_Confederation_-Hydrogen_for_the_Ceramics_Sector-_IFS_Feasibility_Report.pdf.

British Glass “Glass Sector Net Zero Strategy 2050.” (2024) https://www.britglass.org.uk/sites/default/files/British%20Glass%20-%20Net%20Zero%20Strategy.pdf.

British Glass “Recycled Content of Glass Packaging” (2019) www.Britglass.Org.Uk. Accessed August 5, 2026. https://www.britglass.org.uk/knowledge-base/resources-and-publications/recycled-content-glass-packaging.

Calumite. 2014. “Glass Quality - Hanson Calumite.” Hanson Calumite. December 5, 2014. https://calumite.co.uk/the-product/benefits-of-calumite/glass-quality/.

Calumite.” 2014. “How Calumite Works - Hanson Calumite.” December 5, 2014. https://calumite.co.uk/the-product/how-calumite-works/.

Centre for Advanced Sustainable Energy (CASE). A Pathway to Our Renewable Future. Accessed September 16, 2026. https://case-research.net/report/a-pathway-to-our-renewable-future/.

Ceramics UK, “Ceramics UK Reaches Key Milestone in Hydrogen Project,” January 24, accessed July 31, 2026, https://www.ceramics-uk.org/news/ceramics-uk-reaches-key-milestone-in-hydrogen-project

Ceramics UK, Decarbonising UK Ceramic Manufacturing Roadmap: Interactive PDF (Stoke-on-Trent: Ceramics UK, 2024),https://static1.squarespace.com/static/6566f758dd1a4c385d6b7a86/t/65b8d0ce61458d1b000a5963/1706610905794/Roadmap+Interactive+PDF.pdf.)

Department for Business and Trade, Business Population Estimates for the UK and Regions 2025: Statistical Release, GOV.UK, published October 2, 2025, https://www.gov.uk/government/statistics/business-population-estimates-2025/business-population-estimates-for-the-uk-and-regions-2025-statistical-release.

Department for Energy Security and Net Zero. “Evaluation of Hy4Heat Final Report 2.” 2023. https://assets.publishing.service.gov.uk/media/63fe1053d3bf7f25f76ffc8c/evaluation_of_hy4heat_final_report.pdf.

Department for Energy Security and Net Zero, “Hydrogen Allocation Rounds,” GOV.UK, accessed September 16, 2026, https://www.gov.uk/government/collections/hydrogen-allocation-rounds

Department for Energy Security and Net Zero, Future Opportunities for Electrification to Decarbonise UK Industry: A Report for DESNZ (London: Department for Energy Security and Net Zero, 2024), https://assets.publishing.service.gov.uk/media/67295df0541e1dfbf71e8b50/future-opportunities-for-electrification-to-decarbonise-uk-industry.pdf

Department for Energy Security and Net Zero. 2026. “Updating Evidence on Energy Efficiency Potential for UK Industry.” GOV.UK. March 24, 2026. https://www.gov.uk/government/publications/updating-evidence-on-energy-efficiency-potential-for-uk-industry.

Encirc, “Encirc MD Welcomes Planning Approval of UK’s First Hydrogen Production Facility,” Encirc, January 10, 2024, https://www.encirc360.com/2024/01/10/encirc-md-welcomes-approval-of-uks-first-hydrogen-production-facility/.

Energy Advice Hub. *“UK ETS | Emissions Trading Scheme | Frequently Asked Questions | FAQs.”* Accessed September 11, 2026. https://energyadvicehub.org/the-uk-emissions-trading-scheme-frequently-asked-questions/.

Erica Brown, “To Unlock the Potential of Hydrogen, We Need to Embrace Blending at Transmission Level,” The Institution of Gas Engineers and Managers (IGEM), July 2025, https://www.igem.org.uk/resource/to-unlock-the-potential-of-hydrogen-we-need-to-embrace-blending-at-transmission-level.html.

European Commission, “Auctioning of Allowances,” Climate Action – European Commission, accessed May 5, 2026, https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/auctioning-allowances_en

European Commission, “Energy Performance of Buildings Directive,” European Commission – Energy, accessed June 17, 2026, https://energy.ec.europa.eu/topics/energy-efficiency/energy-performance-buildings/energy-performance-buildings-directive_en.

European Commission, “Modernisation Fund,” Climate Action – European Commission, accessed May 5, 2026, https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en

European Court of Auditors, *Special Report 11/2026: Innovation Fund* (Luxembourg: European Court of Auditors, 2026), https://www.eca.europa.eu/ECAPublications/SR-2026-11/SR-2026-11_EN.pdf.

European Hydrogen Observatory. “EU Hydrogen Strategy under the EU Green Deal.” European Hydrogen Observatory, 2025. https://observatory.clean-hydrogen.europa.eu/eu-policy/eu-hydrogen-strategy-under-eu-green-deal.

FEVE (European Container Glass Federation), Glass Packaging Circularity and Cullet (Brussels: FEVE, May 2026), https://feve.org/wp-content/uploads/2026/05/FEVE-position-Glass-packaging-circularity-and-cullet-May-2026.pdf.

Glass Futures, “Completion of First Trials Campaign Marks New Chapter in Glass Futures’ Decarbonisation Mission,” published February 26, 2026, https://www.glass-futures.org/news/completion-of-first-trials-campaign-marks-new-chapter-in-glass-futures-decarbonisation-mission/

Haush, “The Future of Green Hydrogen in the UK: Meeting Net-Zero Goals,” accessed May 6, 2026, https://haush.co.uk/the-future-of-green-hydrogen-in-the-uk-meeting-net-zero-goals/.

Imperial College London, “Centre for Advanced Structural Ceramics” (London: Imperial College London, n.d.) https://www.imperial.ac.uk/structural-ceramics/.

Institution of Gas Engineers and Managers (IGEM) “To Unlock the Potential of Hydrogen, We Need to Embrace Blending at Transmission Level,” (Brown: IGE, 2025), https://www.igem.org.uk/resource/to-unlock-the-potential-of-hydrogen-we-need-to-embrace-blending-at-transmission-level.html.

Institution of Gas Engineers and Managers (IGEM), “Investing in Mains Replacement Is Key to Meeting Our Safety and Environmental Goals: Here’s Why” (Kegworth: IGEM, 2025), https://www.igem.org.uk/resource/investing-in-mains-replacement-is-key-to-meeting-our-safety-and-environmental-goals-here-s-why.html.

IOM3. 2020. “Keeping the Kilns Burning.” Iom3.org. 2020. https://www.iom3.org/resource/keeping-the-kilns-burning.html.

J&B Recycling. (2024). Where does your glass recycling really go? Retrieved May 5, 2026, from https://www.jbrecycling.co.uk/jb-knowledge/where-does-your-glass-recycling-really-go

Jord International, “Biofuels Basics: Exploring Solid, Liquid, and Gaseous Biofuels,” Jord International, accessed September 16, 2026, https://www.jord.one/blogs/biofuels-basics-exploring-solid-liquid-and-gaseous-biofuels.

Khalil, Ahmed M. E., Anne P. M. Velenturf, Masoud Ahmadinia, and Shaowei Zhang. 2023. "Context Analysis for Transformative Change in the Ceramic Industry" Sustainability 15, no. 16: 12230. https://doi.org/10.3390/su151612230

Methagora. 2025. “Industrial Decarbonization: Saint-Gobain Glass Goes for Biomethane in Flat Glass Production.” Methagora.Com. Methagora. December 3, 2025. https://www.methagora.com/en/blog/decarbonation-industrielle-saint-gobain-glass-biomethane-porte.

Nascimento, Marcio Luis Ferreira. 2014. “Brief History of the Flat Glass Patent – Sixty Years of the Float Process.” World Patent Information 38 (September): 50–56. https://doi.org/10.1016/j.wpi.2014.04.006.

Office for National Statistics.“Greenhouse Gas Emissions, UK: Provisional Estimates, 2024.” Statistical bulletin. Released October 24, 2025. Accessed September 23, 2026. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/greenhousegasintensityprovisionalestimatesuk/latest.

Sheikh, A.Y., Barker, B., Markkanen, S. and Devlin, A. (2023). “Glass sector deep dive: How could demand drive low carbon innovation in the glass industry.” Cambridge: Cambridge Institute for Sustainability Leadership (CISL).

Sousa, Jorge, Inês Azevedo, Cristina Camus, Luís Mendes, Carla Viveiros, and Filipe Barata. 2024. "Decarbonizing Hard-to-Abate Sectors with Renewable Hydrogen: A Real Case Application to the Ceramics Industry" Energies 17, no. 15: 3661. https://doi.org/10.3390/en17153661

Sustainability Directory. “Dilute CO_2 Sources.” Accessed September 11, 2026. https://climate.sustainability-directory.com/area/dilute-co2-sources/.

Swan Energy Ltd., “UK Government Explores Including Grid Injected Biomethane in ETS,” September 16, 2025, accessed April 10, 2026, https://swanenergy.co.uk/biomethane-uk-ets/

IDRIC

UK Research and Innovation

We would like to thank the wide range stakeholders of who contributed to IDRIC workshops and stakeholder engagement.

This work was supported by EPSRC funding, award number: EP/Z53125X/1, through the UK Industrial Decarbonisation Research and Innovation Centre (IDRIC).

The views expressed reflect the perspectives shared through stakeholder engagement and do not necessarily represent those of funders.

Find out more at idric.org

