



MPA Lime

Net Negative 2040 Roadmap

CONTENTS

Foreword.....	2
Executive Summary	2
About the UK Industry	3
Decarbonisation Progress to Date	5
Decarbonisation Ambition.....	6
Carbon Capture	7
Fuel Switching.....	8
Product Carbonation.....	8
Indirect and Transport Emissions	8
Enabling Decarbonisation	9
Competitiveness.....	9

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- Front Cover: Origen pilot kiln under construction at Singleton Birch, courtesy of Singleton Birch
- Page 2: Inside of a parallel flow regenerative kiln (PFRK) at Lhoist, courtesy of Lhoist UK
- Page 3: Anaerobic digester, courtesy of Singleton Birch
- Page 4: Hydrogen pressure let-down stations at Tarmac, Tunstead. Courtesy of the Mineral Products Association
- Page 9: Hindlow limestone quarry, courtesy of Lhoist UK
- Page 10: Fossil in limestone, courtesy of Singleton Birch
- Back Cover: Whitwell dolime plant at night, courtesy of Lhoist UK



FOREWORD

Lime products have been manufactured and used for millennia in an astonishingly wide variety of applications, including the construction of Egyptian pyramids, Hadrian's Wall, Roman aqueducts and many cathedrals, as well as in agriculture, art and leather processing.

Since the industrial revolution, lime has been used in the manufacture of steel and glass, and more recently in applications such as emissions abatement from incinerators and in drinking water treatment. In common with other essential industrial minerals, its production also currently generates significant carbon dioxide (CO₂) emissions.

The UK lime sector produces two distinct types of lime products; high calcium lime and dolime, which are manufactured using two very different kiln technologies. The decarbonisation paths of the two kiln types are also very different and are therefore treated separately in this roadmap document as lime and dolime. Where reference is made to both types of products together, the term UK lime sector is used.

Lime is produced by heating quarried limestones or chalks to temperatures of at least 900°C, which transforms the rock into a reactive product called quicklime. When quicklime is carefully combined with water, this makes hydrated lime products, which can be used for applications including drinking water treatment, animal nutrition and sanitation, sugar production, kiln and incinerator flue gas treatment, sewage treatment, and neutralising acidic waste from manufacturing processes.

When lime products are exposed to the atmosphere, they naturally absorb, and permanently store, CO₂ in a reaction called carbonation.

Dolime products are manufactured using a different form of limestone known as dolomitic limestone, which requires even higher temperatures to form dolomitic quicklime or dolime. Dolime is used in applications such as steel and glass manufacturing, the production of kiln and incinerator refractories, and refractory repair products.

UK lime producers have fully acknowledged the need to reduce emissions and tackle climate change. In this roadmap, the

technologies and associated infrastructure that will enable them to decarbonise are identified. Combining this decarbonisation with the natural carbonation of lime and dolime products, the UK lime sector has an opportunity to deliver net negative carbon emissions, absorbing more CO₂ from the atmosphere than it emits.

There are challenges and barriers that must be addressed to realise this net negative opportunity, and in recent years the UK lime sector has made significant and world-leading progress to begin to address these. These actions include a world first trialling of hydrogen fuel in a lime kiln and partnering with third parties on industrial scale trials of an alternative lime production technology, oxy-fuel calcination (where fuels are combusted in oxygen rather than air which reduces the fuel requirement and increases the concentration of CO₂ in the exhaust gas ready for carbon capture) and most recently, the launch of an industrial collaboration known as the Peak Cluster, which aims to capture, transport and permanently store 3 million tonnes per year of CO₂ from five cement and lime plants in Derbyshire from 2030.

The result so far has been an overall reduction in absolute CO₂ emissions of 25% since 2005. However, technical and policy barriers remain, and full decarbonisation of the UK lime sector will require these to be addressed in order to deliver on the objectives of this Net Negative 2040 Roadmap.

"The UK lime sector has already achieved remarkable progress in both business commitment and tangible actions to decarbonise and play its part in tackling climate change. The publication of this Net Negative 2040 Roadmap is a milestone on the journey and serves to communicate, as well as incentivise, the changes that are essential for the future. The pace of change must accelerate, and we are jointly committed to ensuring that it does". Richard Stansfield, Chair of MPA Lime Management Committee.

Executive Summary

The energy intensive nature of lime and dolime production, and the chemical reactions that occur when the calcium carbonate raw materials are heated at high temperature, have long been known to cause significant emissions of carbon dioxide (CO₂) to the atmosphere. The sector is aware of the need to reduce these emissions in response to the challenge of climate change and the UK lime sector is working hard to decarbonise manufacturing whilst maintaining product availability and quality.

This Net Negative 2040 Roadmap shows how the UK lime sector can be fully decarbonised by 2040, and even contribute net negative emissions when the benefits of carbonation are considered.

This roadmap highlights actions and investments to date that have resulted in an absolute reduction in CO₂ emissions of 25% since 2005, before considering the five key levers required to decarbonise remaining emissions from lime and dolime production in the UK: carbonation, fuel switching, carbon capture utilisation and storage (CCUS), indirect emissions (associated with the use of electricity), and transport.

Importantly, reaching and exceeding net zero will require some key enabling action by lime and dolime producers, and also from Government and others. This enabling action to accelerate decarbonisation across the UK lime sector is also set out in this roadmap.

About the UK industry

The UK lime sector produces a range of industrial mineral limes which are used, often as an essential ingredient, across multiple industries and applications from steel, glass, plastics, refractories and paper manufacture; to reducing pollution from energy generation, environmental protection and remediation. Lime products are also used in agriculture and the food chain, including drinking water purification and fertilisers, as well as many uses in construction and civil engineering, to name a few.

UK production in 2022 was approximately 1.2 million tonnes. The Gross Value Added (GVA) for the UK lime sector is around £45m per year⁽¹⁾. This is only a fraction of the GVA of the key industries that utilise this essential material, which the Mineral Products Association (MPA) has estimated to be in excess of £200bn⁽²⁾. Around 250,000 tonnes, or 20% of UK production, consists of specialist products exported to overseas markets.

Lime is produced by heating limestones or chalks (calcium carbonate raw materials) at high temperatures in industrial kilns that operate continuously. Carbon dioxide (CO₂) is emitted from the combustion of fuels to reach the high temperatures (called combustion emissions). In addition, when heated, a chemical reaction known as calcination releases CO₂ from the calcium carbonate raw materials themselves. These emissions are known as 'process emissions' or 'process CO₂' and make up 60 to 70% of the total emissions from lime and dolime production.

The resulting calcined lime (known as quicklime) can be used in various applications or, with controlled addition of water, it can be used in the form of hydrated lime products, which can be made to a range of designed characteristics.

Many of the applications of lime products in use cause them to be exposed to atmosphere either immediately, or over a more extended period. With this exposure, the lime chemically reacts with CO₂ present in the atmosphere, permanently capturing it as the lime returns to a form of limestone. Recent research (see section on product carbonation) has determined that across major lime product applications, approximately 33% of the total process CO₂ emitted during production is reabsorbed, with much of this occurring within the first year.

⁽¹⁾ MPA data ⁽²⁾ UK Minerals Forum UK Mineral Strategy 2018

Decarbonisation Progress to Date

There has been significant progress made in production efficiency through investments in best available kiln technology, improvements in fuel efficiency and, in the case of dolime production, fuel switching away from fossil fuels to waste derived alternatives. These savings have resulted in CO₂ emissions from fuel combustion for dolime being reduced by 38% since 2005.

High purity lime products are essential for applications such as water treatment and food production. Lime manufacture is

therefore dependent on clean burning fuels (e.g. natural gas) as impurities present in alternative fuels would negatively impact on lime quality and prevent its use in these essential applications.

The applications for dolime products are less sensitive to the inclusion of low levels of impurities in fuel, which has enabled the careful selection of alternative fuels, including biomass and industrial solid wastes, to be introduced to replace fossil fuels, without compromising product quality.

Indirect (scope 2) emissions associated with the electricity consumed in the production of lime and dolime have also been reduced. UK lime producers source the majority of their electricity from renewable sources, and investments have been made in Anaerobic Digestion (AD) and Combined Heat and Power (CHP) to generate renewable electricity onsite.

Singleton Birch have built 3 AD plants to provide renewable energy from agricultural feedstocks and wastes. The combined production of the 3 plants is more than 3MW of electricity and is the equivalent of over 90% of the electrical demand of the lime production facilities at Melton Ross.

The CHP project installed by Lhoist reduces efficiency losses in power supply in two areas. Firstly, by installing a generator on-site it avoids the inevitable losses during transportation of electricity over the grid. Secondly, it recuperates energy normally lost as waste heat, by utilising the heat from the generator in a specialist lime production process. 1.3MW per year of heat energy is recovered that would otherwise need to be provided by burning natural gas, as well as provision of 2MW per year of high efficiency electricity for lime production.



Decarbonisation Ambition

Lime and dolime manufacture are energy intensive processes. The need to reduce CO₂ emissions to tackle climate change and to enable the UK to achieve its Net Zero target is recognised.

The UK lime sector aims to deploy carbon capture, utilisation, and storage (CCUS) at the first sites in the next seven years so that the sector rate of decarbonisation can outpace the direction set by the Government in its Industrial Decarbonisation Strategy. Combining the use of biomass fuels with CCUS and by taking account of

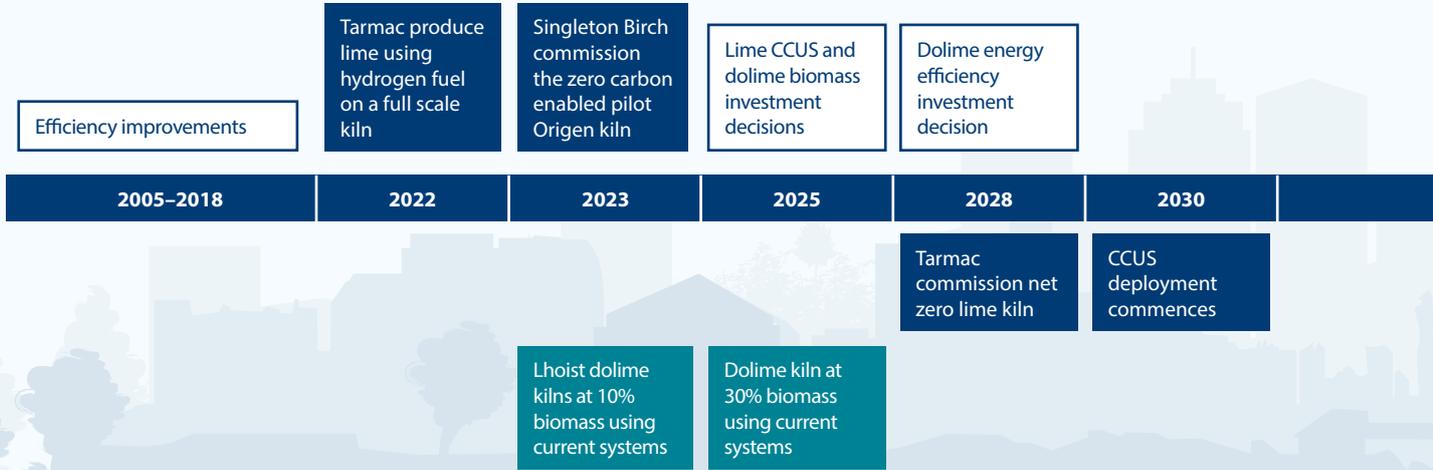
carbonation of lime products in use, the UK lime sector can absorb more CO₂ from the atmosphere than is emitted in production and help to offset other hard to abate emissions.

The diagrams on pages 5 and 6 show the UK lime sector timelines to net negative emissions and waterfall charts demonstrating the technologies required to decarbonise to net negative emissions.

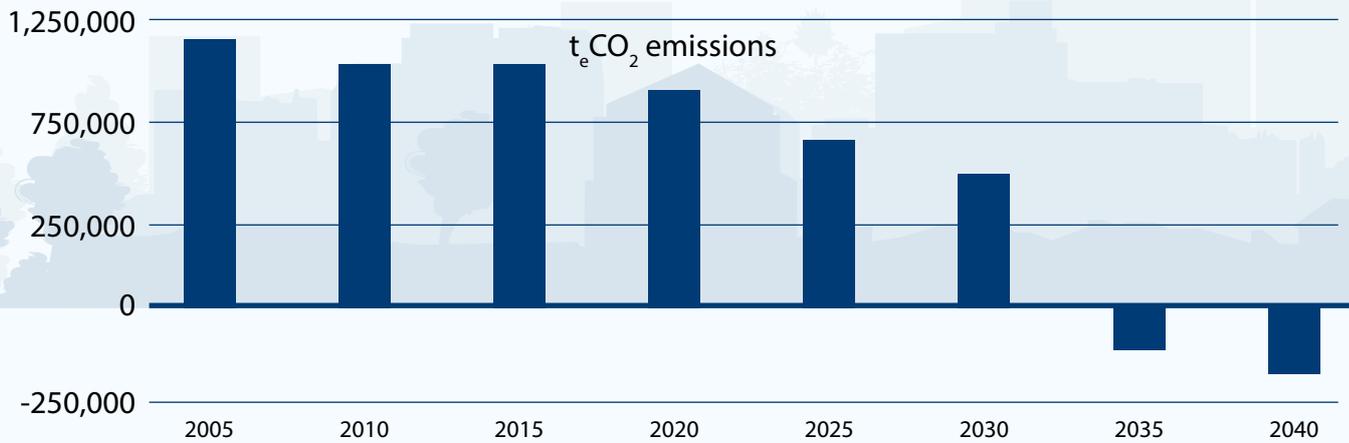
With the right policy and business environment, lime production would reach net negative emissions by 2035, and dolime production by 2038, well ahead of the Government trajectory for the UK of net zero by 2050.



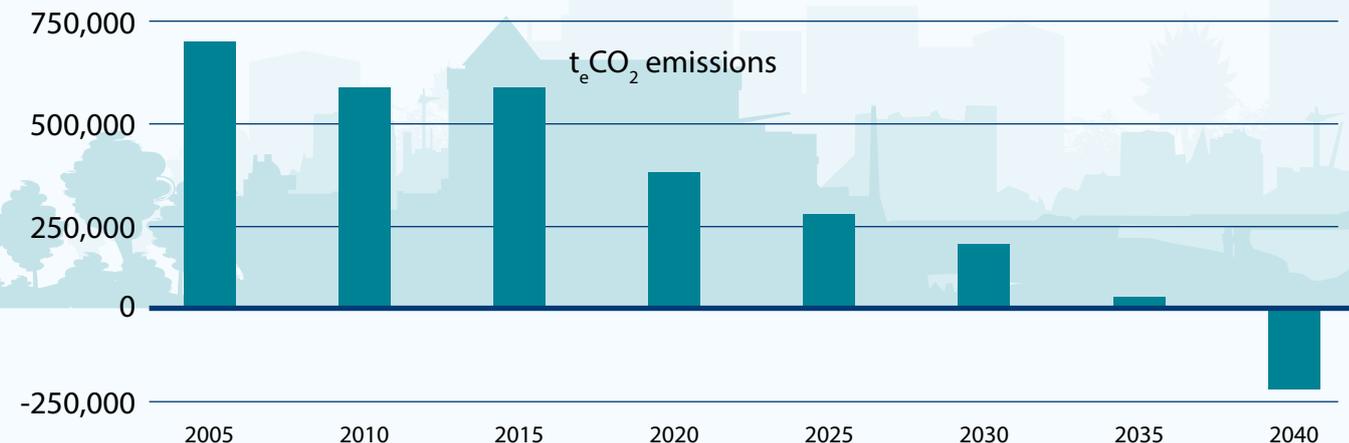
Timeline to Net Negative

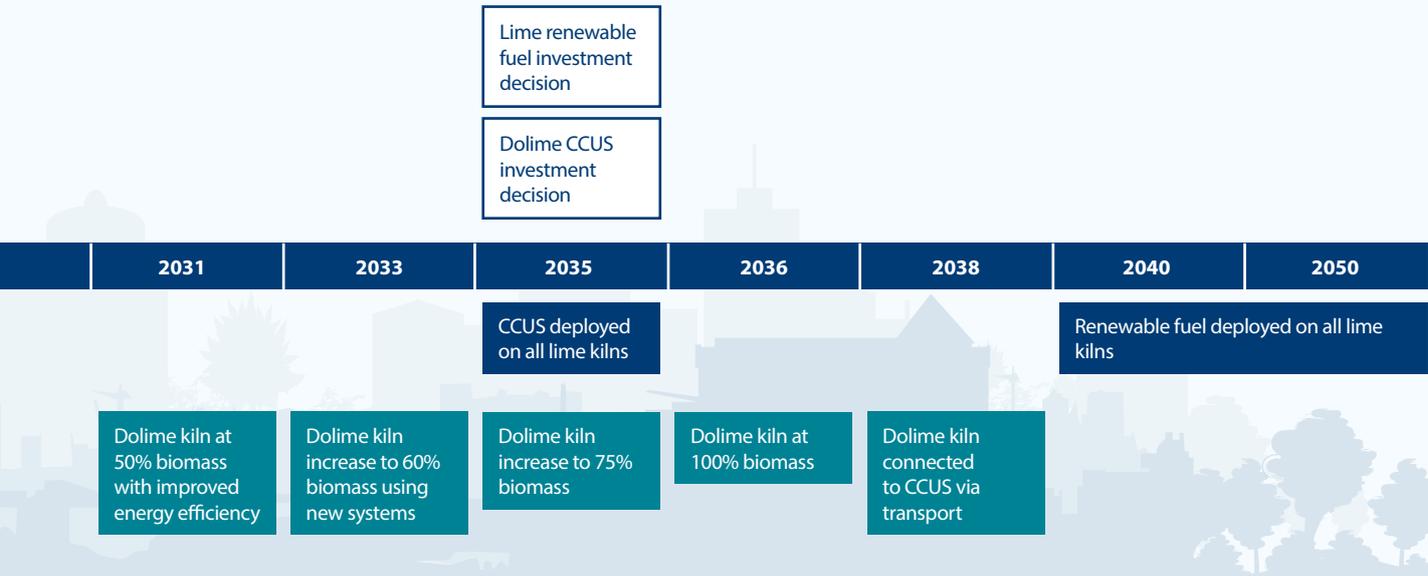


Lime Decarbonisation Lime manufacturing hits net negative by 2035

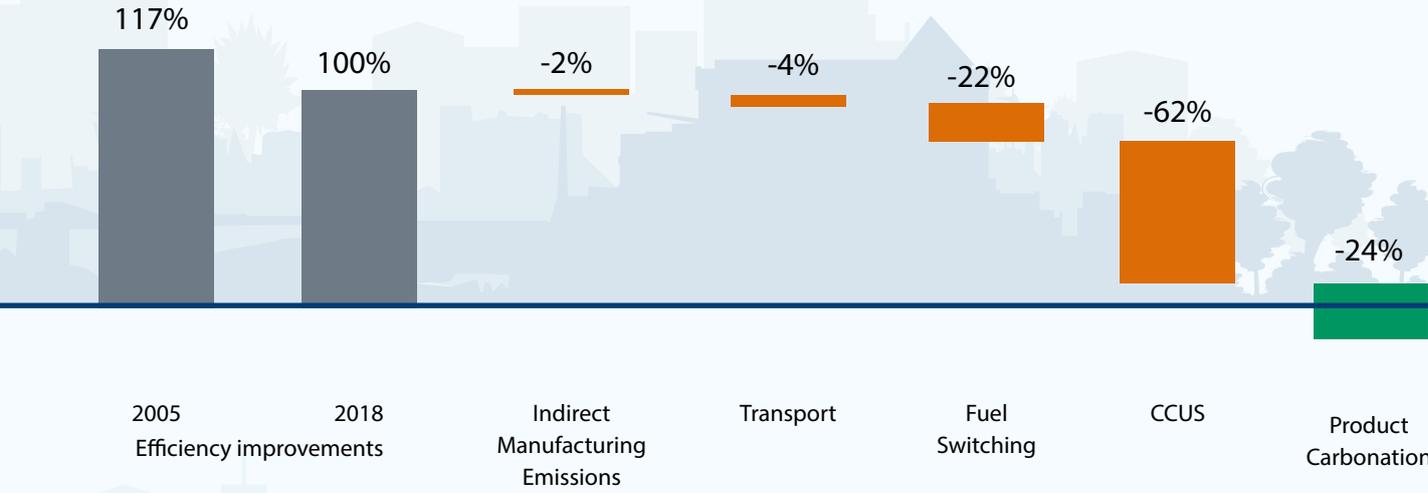


Dolime Decarbonisation Dolime manufacturing hits net negative by 2038

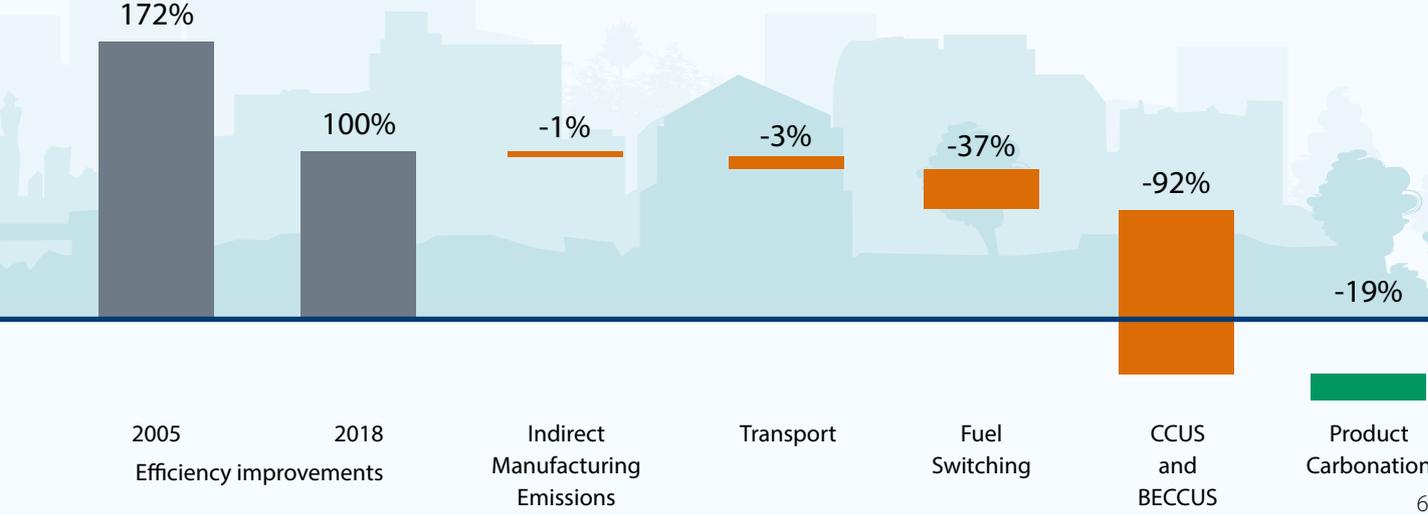




Waterfall diagram of decarbonisation actions



Waterfall diagram of decarbonisation actions



Carbon Capture

The high level of process emissions mean that carbon capture is fundamental to decarbonising lime and dolime production. Whether the captured CO₂ is utilised or stored will depend on developments in the carbon capture and related industries and the direction of Government policy. The utilisation or storage of CO₂ is unlikely to be close to the production sites and the quantities produced mean that the CO₂ will ideally need to be transported via pipeline.

MPA Lime members are already actively involved in the development of CCUS:

- Singleton Birch manufacture lime in the East Coast Cluster. The Zero Carbon Humber Cluster is a 'Track 1' cluster with ambitions to decarbonise the region by 2040. Singleton Birch aim to have kilns connected to CCUS by 2035 and to be running on hydrogen fuel by 2040.

- Tarmac and Lhoist both manufacture lime in the heart of Derbyshire, near Buxton. They are part of a collaboration known as the Peak Cluster that recently launched and which aims to capture, transport and permanently store over 3 million tonnes of CO₂ per year from 2030. These plants are also planning to be using hydrogen fuel by 2040.
- Lhoist run the only dolime facility operating in the UK. Reliant on solid fuels, early decarbonisation will come through efficiency gains and the use of biomass fuels. The plant at Whitwell in Nottinghamshire is an example of a 'dispersed site', a site located in a rural, isolated location and not near other industrial CO₂ emitters.

Deployment of carbon capture at the dolime facility will deliver **'BECCUS'** – Bioenergy Carbon Capture, Utilisation and Storage which is a negative emission technology that actively removes CO₂ from the atmosphere.

CO₂ removals through BECCUS and product carbonation mean that **from 2040 the UK lime sector expects to remove around 250,000 tonnes of atmospheric CO₂ every year**

UK Lime sector decarbonisation

Factory/Site Owner	Location
	Buxton 1
	Whitwell 2
www.lhoist.co.uk	
	Melton Ross 3
www.singletonbirch.co.uk	
	Tunstead 4
	Hindlow 5
www.tarmacbuxtonlime.com	



Fuel Switching

Hydrogen or biomethane have excellent potential to replace natural gas for lime manufacture.

Dolime is reliant on solid fuels to achieve higher temperatures so will need access to waste biomass or alternative low or zero carbon solid fuels to decarbonise.

New kiln technologies are being researched and once proven will support the transition to net zero by enabling a wider choice of net zero fuels.

Demonstrating the use of hydrogen fuels

Funded by the Government's Energy Innovation Programme, a project carried out at the Tarmac Tunstead site in 2022 successfully demonstrated the use of hydrogen as a fuel to manufacture lime. The world-first project provided greater understanding of the challenges of fuel switching, including how to distribute energy across the kiln to produce lime to the required standards. Following the demonstration, lime manufacturers are confident that these and other challenges can be overcome to enable the use of hydrogen in lime production.

Clean technology innovation

Singleton Birch Ltd. has partnered with Origen Power to develop new kilns based on oxy-fuel calciner technology as a route to zero carbon lime production. Oxy-fuel technology, where fuels are combusted in oxygen rather than air, reduces the fuel requirement and increases the concentration of CO₂ in the exhaust gas ready for carbon capture.

A pilot plant commenced construction in 2022 and when fully commissioned, the plant will have a 3,000 tonnes per year lime capacity. Once the technology is proven, the next stage will be a 50,000 tonnes per year kiln, which is already in design.

Product Carbonation

Throughout their lifetime when lime products are in contact with the atmosphere, there is a natural reversal of the reaction that generated the process emissions in the kiln. CO₂ from the atmosphere is absorbed and returns the lime back to a limestone-like material. This process removes CO₂ from the atmosphere without any energy consumption and permanently locks it away.

A recent study⁽³⁾ commissioned by the European Lime Association (EuLA) shows that, across major applications of lime, around 33% of the process CO₂ emitted during lime production is captured permanently by carbonation during use.

Although there are differences between the wide-ranging uses of lime, 95% of the carbonation reactions have been found to occur within the first year of their life.

⁽³⁾ See EuLA website - www.eula.eu

Indirect and Transport Emissions

The sector is reliant on others to decarbonise indirect emissions associated with electricity consumed by the sector, and emissions associated with the transport of lime to customers and the quarry vehicles used on site.

The Government's Industrial Decarbonisation Strategy sets out a trajectory to reduce the carbon emissions from these sources and investment will be needed in the equipment and vehicles that are used, as well as the infrastructure needed to charge or fuel them.

Enabling Decarbonisation

Government and industry will need to work in close collaboration, to build a shared understanding and pathway to net zero; one where policy, financial and infrastructure enablers are coordinated to support the UK lime sector's decarbonisation and to manage a just transition. This section outlines the enabling actions required for the UK lime sector to achieve net negative emissions by 2040.

Key Takeaways

- 1 Industry and Government must work in close collaboration to develop a shared understanding and pathway to net zero.**
- 2 A 'just transition' to net zero should not compromise the competitiveness of British manufacturing and jobs nor export emissions abroad.**
- 3 Long-term investment from Government will be required to support essential energy intensive industries to decarbonise.**

CO₂ Accounting

- Set a national net zero goal on consumption emissions, in addition to current targets for territorial emissions, to ensure net zero is not met or partially met by closing British manufacturing and importing goods instead.
- Improve the accuracy of UK emissions reporting by ensuring national greenhouse gas accounting includes the CO₂ permanently captured and stored by the carbonation of lime, as has been achieved for the cement sector.

Regulation

- Ensure that the UK electricity system is regulated to provide decarbonised electricity at internationally competitive prices to lime producers throughout the transition to net zero and beyond.
- Provide regulatory certainty in climate change policies such as the UK Emissions Trading Scheme (UK ETS), in order to create long term visibility for company capital investment programmes, which have long payback periods. This would include a fair and achievable UK ETS benchmark for lime.

Infrastructure

- Provide a plan for and support the construction of a CO₂ transport and storage (T&S) network available to all UK lime producers and underwrite the main costs and risks of T&S.
- Support the development of a zero carbon gas (hydrogen/ biomethane) network and market at cost competitive prices.

Finance

Provide financial support to assist energy intensive industries with transitional support for research, innovation and deployment of low carbon technologies, including:

- Deliver funding to enable the required infrastructure for large volume zero carbon gas production and transport.
- Support the provision and use of biomass and waste biomass in directly fired operations / industrial combustion activities.
- Deliver funding for the required infrastructure of large volume carbon capture and transport.
- Provide financial support for the development of carbon capture projects to attract investment to the UK.
- Set out a long term business model to support the capital and operational costs of CCUS, for projects beyond Track 1, Phase 2, so that the technology can be more widely developed and deployed.
- Support the development of CO₂ utilisation processes and markets for products consuming captured CO₂ to reduce long term storage.

Competitiveness

UK lime producers compete in an international market. If they were to pass high operating costs through to their customers, those customers would source lower cost lime imported from abroad or search for alternative non-lime products, where they exist. In export markets, British manufacturers could lose market share to local lime producers or locally produced materials that do not have the same direct and indirect carbon costs. Thus, the UK lime sector's domestic and export sales are both at risk of carbon leakage as a result of higher UK carbon costs.

While the UK lime sector faces higher energy and carbon operating costs than competitors elsewhere, policies are required to mitigate carbon leakage and ensure a competitive domestic UK lime sector. This requires:

- Retention of free allocation in the emissions trading system until a more effective carbon leakage mitigation mechanism can be implemented.
- Delivery of the proposals announced in the British Industry Supercharger to help level UK industrial electricity costs with competitors overseas. Ensuring that the UK lime sector remains eligible for these support measures, which include an increase in the Energy Intensive Industries (EII) exemption from 85% to 100%, introduction of an exemption from capacity market costs and a discount on network charges that recognises the contribution EII's make to system balancing.
- Introducing a Carbon Border Adjustment Mechanism (CBAM) that balances unequal international carbon prices and is designed to ensure no detrimental impact on the competitiveness of UK lime exports.







MPA Lime is part of the mineral products association the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries. www.mpalime.org

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