

**IMPERIAL**

# Business Development 3 (Business Planning)

CCUS Innovation 2.0

Key Knowledge Deliverable 5.3

## **Key Knowledge Deliverable Cover Sheet**

This Key Knowledge Deliverable (KKD) has been produced by Imperial College London as part of the Department for Energy Security and Net Zero £1bn Net Zero Innovation Portfolio (NZIP) - CCUS Innovation 2.0 programme. The document is reflective of the status of the project at the time of writing. The material presented could have been subject to change as the project matured. These documents should not be considered a full representation of the final project.

### **Project Description**

This project seeks to further develop and scale a new carbon sequestration process which transforms waste CO<sub>2</sub> gas from industrial facilities into valuable construction products. Sequestered CO<sub>2</sub> through this process is cheaper than conventional approaches that rely on purification, liquification and offshore or geological storage. The CO<sub>2</sub> is stored in the form of a stable mineral which ensures they will be no leakage over time.

The patent-pending technology involves taking globally abundant magnesium silicate minerals and splitting this into magnesia and silica components. Through simple chemical processing two products of high purity are created: a) an amorphous silica that can be used as supplementary cementitious material (SCM) to facilitate low-carbon concrete and b) a concentrated magnesium solution in which CO<sub>2</sub> from industrial flues can be sequestered to produce other construction materials.

This CCUS Innovation 2.0 award will be used to increase our technology and commercial readiness level by de-risking and facilitating the development of a pilot facility, in order to demonstrate that the technology is economically viable and deployable at scale.

### **Description of KKD**

Report detailing business development activities in this quarter of the project, including: business opportunities, partnerships, and pilot and demonstration projects. Particular focus on business planning, using supply chain learnings from D5.2 to finalise a route to market and business plan for the next 20 years, making use of various intermediate markets.

### **KKDs to be released in full**

- D3.4 – Concrete Trials 3
- D4.4 – Product Optimisation 2

### **KKDs to be released after redactions**

- D1.1 – Flue Gas Recovery and Testing 1
- D1.2 – Dissolution Procurement
- D1.3 – Dissolution Operation
- D1.4 – Flue Gas Recovery and Testing 2 & Carbonation Procurement
- D1.5 – Carbonation Operation
- D2.3 – Reagent Regeneration Procurement
- D2.4 – Reagent Regeneration Operation
- D3.2 – Concrete Trials 1
- D3.3 – Concrete Trials 2
- D4.2 – Process Optimisation
- D4.3 – Product Optimisation 1
- D5.2 – Business Development 2 (Supply Chain)
- D5.3 – Business Development 3 (Business Planning)
- D5.4 - Business Development 4 (Commercial Readiness)
- D6.1 – Year 1 Report
- D6.2 – Year 2 Report



© Crown copyright 2026

This publication is licensed under the terms of the Open Government Licence v3.0 except where otherwise stated. To view this licence, visit [nationalarchives.gov.uk/doc/open-government-licence/version/3](https://nationalarchives.gov.uk/doc/open-government-licence/version/3) or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or email: [psi@nationalarchives.gsi.gov.uk](mailto:psi@nationalarchives.gsi.gov.uk).

Where we have identified any third-party copyright information you will need to obtain permission from the copyright holders concerned.

Any enquiries regarding this publication should be sent to us at:  
[nzip@energysecurity.gov.uk](mailto:nzip@energysecurity.gov.uk)

---

# Contents

Business Description and History	6
Seratech's Unique Value Proposition	6
Business History	8
Awards and Media	8
The Technology	9
SCM	9
MagCarb Construction Products	10
Supply and Product Markets	12
Magnesium Silicates	12
CO2 Sequestration	14
Silica, Supplementary Cementitious Materials and Cement	18
Magnesium Carbonate and Construction Products	21
Licensee Business Model & Techno-Economic Analysis	24
Target Licensees	24
Assumptions for Techno-Economic Analysis	26
Techno-Economic Analysis	27
Business Development and Growth	27
Phase 1 – Research and Development (2021 –2024)	28
Phase 2 – Pilot (2025)	28
Phase 3 – Industrial Pilot (2026 – 2027)	28
Phase 4 – Licensing and Scale-Up (from 2027)	29
8 Team	29
8.1 Board of Directors	29
Technical Team	30
Commercial Team	31
SWOT Analysis	32

# Business Description and History

## Seratech's Unique Value Proposition

Seratech has developed a unique Carbon Capture, Mineralisation and Utilisation (CCMU) process. This is a solution to two of society's biggest needs: affordable carbon capture and sustainable building materials.

Through a single process, Seratech derives three sources of value:

**CO2 Sequestration** – industrial emitters registered with the UK or EU Emissions Trading System (ETS) are required to purchase Allowances for each tonne of CO2 they emit. By implementing Seratech's process, their emissions will be sequestered, and they will avoid the need to purchase Allowances.

**Silica** – this low carbon product of the Seratech process can be used as a supplementary cementitious material (SCM) to replace up to 50% of Portland cement in concrete. With supplies of existing SCMs (such as GGBS and fly ash) dwindling and prices increasing, Seratech's SCM is a high-performing alternative.

**MagCarb** – this low carbon product of the Seratech process can be used as an alternative to Portland cement in many construction products, including concrete blocks, bricks, and boards and offers alternatives to incumbents with drastically reduced embodied carbon and cost.

Seratech presents a unique business opportunity that combines large scale impact across a global market, using patent-pending technology that can be translated into existing commercial and regulatory frameworks. It is borne from authentic research at a world-leading academic laboratory and has an experienced and high-power team behind it. At Seratech we set out to solve the challenge of decarbonising the construction industry, allowing concrete to continue to satisfy the world's need for safe, reliable and affordable construction, but with zero CO2 emissions.

Globally, governments have declared their goals to achieve net-zero CO2 emissions by 2050. The industrial sectors responsible for these emissions are publishing roadmaps indicating how they will achieve these goals. In order to reach these targets, many sectors are seeking a 50% emissions reduction as early as 2030. Carbon capture and storage (CCS) is central to many of these strategies. The CCS industry is still in its infancy but is forecast to grow rapidly, with the potential to become a globally dominant sector, comparable to energy. The current CCS approaches require expensive processes and significant public grants to make the processes economical for the private sector as well as requiring specific local geologies to enable underground or undersea storage.

## Business Development 3 (Business Planning)

However, Seratech will sequester carbon and make a profitable return (after capital costs) due to the additional revenue from its three income streams. It does not need to be located near carbon sequestration sites.

Seratech is an R&D business, that will generate revenue by licensing its technologies to industrial emitters, allowing them to sequester their own emissions and profit from the products. The licence fee will be calculated as a proportion of the current ETS price.

## Business History

Seratech is a spin-out from Imperial College London, founded by PhD students Sam Draper and Barney Shanks with support from academic and industry experts. The company was incorporated on 7th July 2021 to commercialise research arising from its co-founders in the field of CO2 capture and construction material innovation.

The team have raised over £1.8m in grant funding at Imperial College London from a range of sources including Engineering and Physical Sciences Research Council (EPSRC), Higher Education Innovation Fund (HEIF) and most recently, a £1.25m grant from the Department for Energy Security and Net Zero (DESNZ) as part of their £1B Net Zero Innovation Portfolio (NZIP).

These grants have funded the laboratory development of the technology, including growing the size of the research team to 5 full time researchers.

The patent application for the core technology was filed with the UK and European patent offices in January 2022.

Seratech has been supported by equity-free accelerator programmes from Undaunted (formerly the Centre for Climate Change Innovation), Sustainable Ventures and the World Wide Fund for Nature (WWF).

## Awards and Media

In October 2022, Seratech was presented with the [2022 OBEL AWARD](#), an international prize that honours outstanding architectural contributions to human development, at a ceremony in Aalborg, Denmark.

In August 2023, Seratech CTO and Co-founder, Barney Shanks, won the [2023 Hawley Award](#).

In March 2024, Seratech won Gold and Silver at the [Engineering Matters Awards](#) in the categories of “Innovation Champion” and “Net Zero Champion”, respectively.

In May 2024, Seratech won the award for “Built Environment – Promising Solution” at the [Innovation Zero Awards 2024](#).

Seratech is featured as a case study in The Green Construction Board’s “[Low Carbon Concrete Routemap](#)” and listed as a technology with the highest potential impact to reduce the sector’s carbon emissions.

Seratech has featured on TV on [BBC News](#) and in a range of high-profile articles in the mainstream media including [CNN](#) and [Forbes](#), and in industry publications such as [Building Magazine](#) and [Wallpaper\\*](#).

# The Technology

Seratech's Carbon Capture, Mineralisation and Utilisation (CCMU) process sequesters waste CO<sub>2</sub> from industrial flues in naturally abundant magnesium silicate minerals, such as olivine. This process transforms the magnesium silicates into two valuable products for the construction industry: Silica which can be used as a supplementary cementitious material (SCM) in concrete and MagCarb which can be turned into a range of construction products.

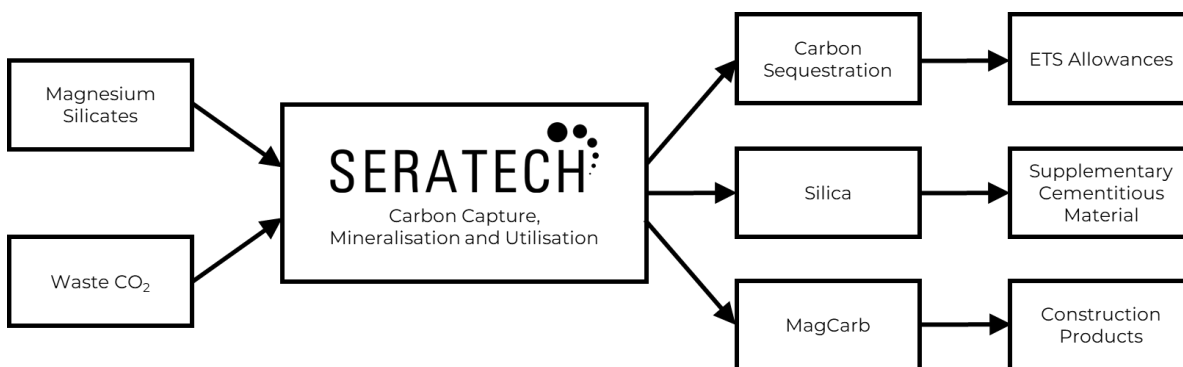


Figure 2.1 – Flow chart showing the inputs, outputs, and products of the Seratech process.

## SCM

The role of SCMs in ready-mix concrete is to replace some of the carbon intensive Portland cement in the mix. Decreasing the amount of Portland cement results in a concrete with lower embodied CO<sub>2</sub>. The SCMs provide a secondary, reaction that complements the cement hydration, and contributes to the strength and durability of the concrete.

### Regulatory Landscape

The silica SCM produced by Seratech has similar chemical and physical properties to existing SCMs, such as fly ash. As such, it conforms with the Standard definitions for a “Natural Pozzolan” in the standards, and can be used a “P” class SCM (as defined in the British and European Standard, EN 197-1) to produce two types of cement: CEM II and CEM IV. Both of these cement types can be used in ready-mix concrete, in the UK and Europe. Figure 2.2 below summarises the landscape for UK cement and concrete Standards.

In a CEM II, up to 35% of the Portland cement in concrete may be replaced by Silica. In a CEM IV, this is increased to 55% maximum replacement level.

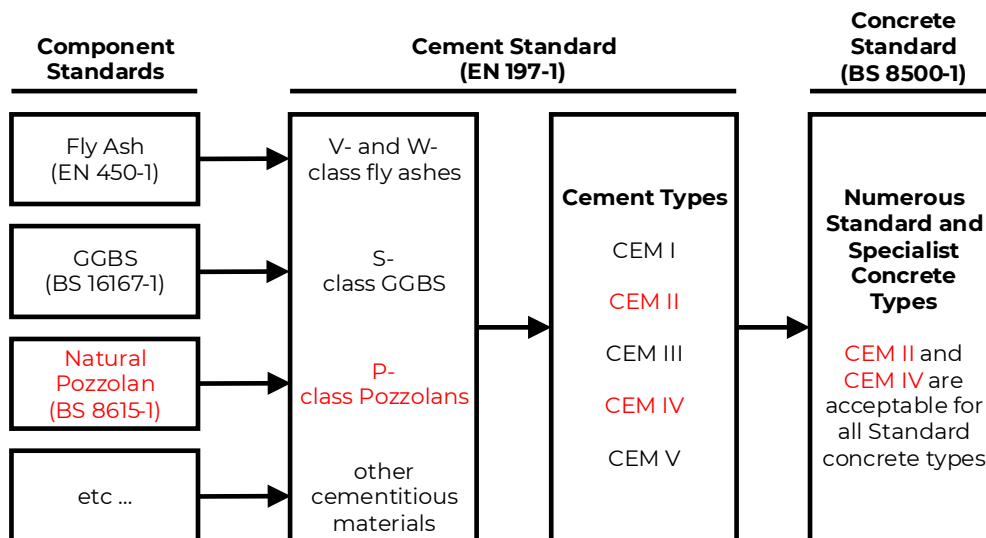


Figure 2.2 – A summary of the Standards flow for cement and concrete in the UK. Items in red are directly relevant to Silica.

## Performance

Reactivity testing has shown that the Seratech Silica is more reactive than fly ash.

A composite cement containing 40% Silica (CEM IV/B-P) shows a 20% increase to 28-day compressive strength and a 50% increase to 3-day compressive strength versus 100% Portland cement (CEM I). This high-performance and rapid strength gain ensures there is no impact to construction programs.

A comprehensive testing regime is currently being undertaken to verify all aspects of performance, including long-term durability. Seratech also has samples with major industry players' labs for independent verification of our testing.

Initial Carbon Assessments for the Silica and some relevant composite cements and concrete mix designs can be found in the Data Room and show a 92% reduction in concrete CO<sub>2</sub> / m<sup>3</sup> when combined with a cement from a plant with CO<sub>2</sub> sequestered by the Seratech process.

## MagCarb Construction Products

MagCarb can be used as a binder in a range of construction products. Seratech will develop the markets in the following order:

**Blocks** – MagCarb acts as a low carbon alternative binder to cement in lightweight and dense concrete blocks (breezeblock). These are typically used for inner walls in residential and commercial building. The most commonly used block is a 7.3 Nmm<sup>-2</sup> medium dense block.

**Bricks** – an alternative to the classic red house brick. There are many classes of concrete brick from high strength engineering bricks to facing bricks and façade materials.

## Business Development 3 (Business Planning)

**Boards** – an alternative to sheet materials such as gypsum-based plasterboard that are typically used for internal finishing.

In each of these products, the MagCarb binder works in the same way. It is mixed with water and other components such as aggregates and/or fibres. This mix is cast or pressed into a mould and cured in a low temperature oven. Initial set is achieved within 3 hours at 60 °C, at which point the product can be removed from the oven and the curing will continue until full strength is achieved within 28 days. This process can be achieved using existing equipment in brick, block and board factories.

Table 2.3 – A summary of typical mix designs for each type of construction product.

Product	Production Methodology	Water Content	Aggregate Content	Fibre Addition
Block	Pressed	Low	High	No
Brick	Pressed, Extruded or Cast	Low to Medium	Medium	No
Board	Cast	High	None to Low	Optional

## Bricks and Blocks

In work to date, bricks and blocks have been developed concurrently, allowing the impact of different production methodologies and mix design parameters to be evaluated and the most suitable identified for each product.



Figure 2.4 – Specimens for testing, made with a range of brick and block mix designs.

## Business Development 3 (Business Planning)

The Standards for these products is EN 771-3 (Aggregate concrete masonry units) and is entirely performance based. Current testing has achieved compressive strengths of up to 20 Nmm<sup>2</sup>. Units have been produced from mix designs representative of concrete blocks and have been able to consistently exceed the 7.3 Nmm<sup>2</sup> compressive strength target.

Water absorption testing has yielded better results than conventional clay bricks and demonstrates that MagCarb bricks and blocks are compatible with hydraulic mortars, eliminating the need for further research into a complete façade system.

A comprehensive testing regime is currently being undertaken to verify all aspects of performance required by EN 771-3, using the standardised methodologies as set out in EN 772.

### **Boards**

Plasterboard definitions, performance requirements and test methodologies are governed by EN 520. This includes “technical characteristics” of the product itself (eg flexural strength, water adsorption, and density) and “system characteristics” of how the product interacts with the building (eg shear strength, fire resistance, impact resistance, sound insulation and acoustic absorption).

Board products are given a letter-Type designation (eg Type A) based on their performance across a range of standardised tests. This designation would be given by a specifier in the design of a building. Since EN 520 is performance-based there is no prescriptive list of allowable components in the mix design, only that the performance requirements are met during testing.

Limited testing has been conducted on board specimens to date, however, results from low-aggregate block mixes, suggests that even high-performance boards should be achievable. MagCarb may offer significant benefits in some aspects of performance, such as fire resistance and water resistance.

Initial Carbon Assessments for a range of MagCarb construction products can be found in the Data Room.

# Supply and Product Markets

## Magnesium Silicates

Magnesium silicate, such as olivine is the core mineral feedstock for Seratech's process.

Olivine is a magnesium-iron silicate (Mg,Fe)<sub>2</sub>SiO<sub>4</sub> and is generally comprised of a mix of forsterite (Mg<sub>2</sub>SiO<sub>4</sub>) and fayalite (Fe<sub>2</sub>SiO<sub>4</sub>). To maximise the carbon sequestration potential of the Seratech process, olivine that is predominantly forsterite is desirable.

Olivine is one of the most abundant minerals in the Earth's crust, with large deposits identified throughout the UK and Europe, and future markets of interest, including South East Asia, the Middle East and the US. A map of these deposits is given in Figure 3.1.

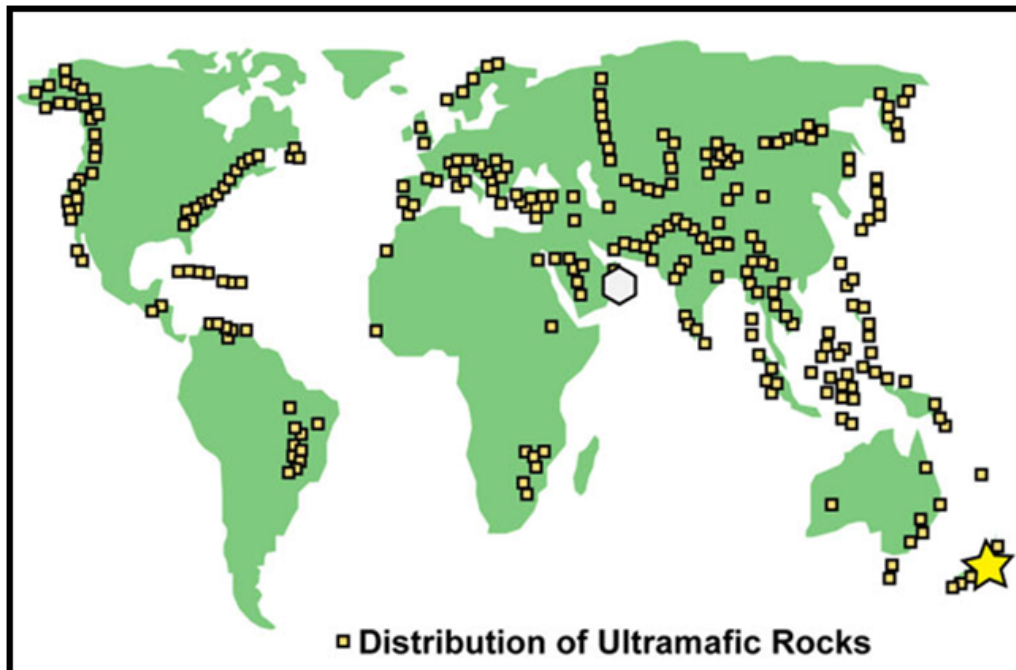


Figure 3.1 – Global distribution of olivine (ultramafic) sources.

These deposits are typically very large and pure, with high forsterite contents. One deposit in Oman (indicated by the white hexagon on Figure 3.1) is predicted to contain 120 trillion tonnes of olivine – enough to sequester the entire emissions from the cement industry (at current levels) for 27,000 years.

### Suppliers

We are currently in discussions with three major suppliers of olivine to establish supply chains for our early pilots and licensing deals:

- **Sibelco** are the largest European supplier of olivine, with current production of over two million tonnes per year, and capacity within existing mines to drastically increase this at short notice. Their main quarry is in Åheim, Norway, which provides easy shipping access to many European locations, including the UK. We have used material from this quarry for our R&D work to date, and expect to continue to use this supply for the two pilot stages and early licensing deals (subject to appropriate locations).
- **Grecian Magnesite** primarily extract magnesite (magnesium carbonate) from a quarry in Chalkidiki, Greece. Veins of this mineral runs through large olivine deposits which have to be excavated to reach the magnesite. This quarry produces over one million

## Business Development 3 (Business Planning)

tonnes per year of by-product olivine, and existing stockpiles from nearly 60 years of quarrying. That Grecian Magnesite have only begun selling the “waste” olivine in the past few years demonstrates the interest the mineral is currently receiving, particularly for its carbon sequestration potential.

- **Carbon Meta** are a US-based technology and resource reclamation company who have access to over 100 million tonnes of olivine. We are exploring potential partnerships as a materials supplier and also a licensee of Seratech’s technology.

Each of these sources are approximately 90%+ forsterite, making them excellent for carbon mineralisation and the Seratech process. These chemical compositions have been verified by the supplier’s datasheets and our own chemical analyses.

### Pricing

We are currently in contact with commercial teams at Sibelco and Grecian Magnesite to establish:

- Volumes they can supply and how this would be shipped
- Size fractions
- The associated cost per tonne, ex-works.

Early conversations indicate run of mine olivine in large quantities will cost around £15 per tonne (USD 19) loaded onto the ship. This would be suitable to supply a licensed facility, with equipment for on-site grinding. Including shipping and grinding, the final price of the olivine has been conservatively estimated at £50-60 per tonne in subsequent economic modelling.

The initial Pilot will not have the capacity to process the olivine, so we will purchase pre-ground Olivine at a premium price. The Pilot is not intended to make a profit, and this cost premium is included in the financial forecasts.

## CO2 Sequestration

### Emissions Trading System (ETS)

The UK and EU both have their own version of the ETS. These schemes are seen as key government-led drivers of the decarbonisation of power generation and other heavy industry.

Under the current Phase of the EU ETS, a country is allocated a number of “Allowances” which are then allocated or auctioned to emitters. At the end of each year, the emitters must surrender enough Allowances to cover their CO2 emissions. If the emitter does not have sufficient Allowances they must obtain more through purchase or trading with emitters holding excess.

## Business Development 3 (Business Planning)

Over time, a country's total allocations are reduced by a fixed percentage (1.74% per year from 2013 to 2020 and 2.2% from 2021 to 2030) in order to achieve total emission reductions within the ETS sector by 43% relative to 2005.

Heavy industry currently receives some free allocations from governments (to maintain competitiveness with foreign products with less stringent carbon regulations)

Current and recent historical allowance prices are given in the figures below for the EU and UK.

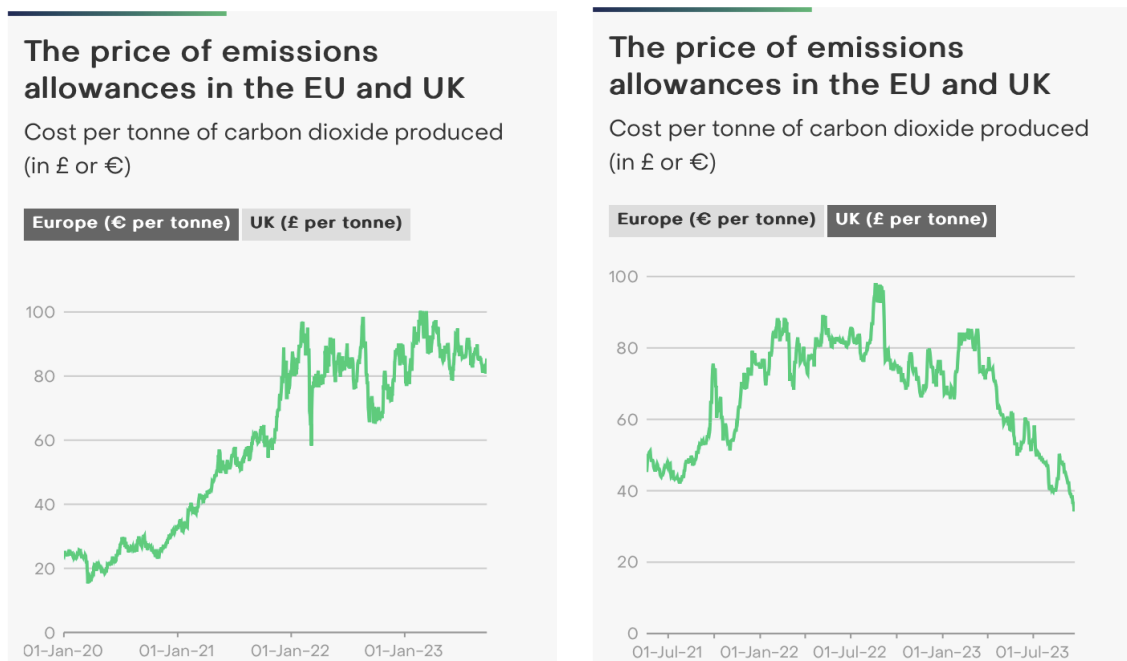


Figure 3.2 – Historical price of emissions allowances (1 t CO<sub>2</sub>) under the EU and UK ETS.

### Carbon Border Adjustment Mechanism (CBAM)

This scheme is designed to minimise carbon leakage across borders and prevents companies from avoiding taxation by importing carbon intensive products. Imports on certain goods (including cement) will be liable for border taxes/duties calculated from the current EU ETS allowances and price. The implementation of a CBAM will lead to the acceleration of the removal of free Allowances in certain sectors (cement, steel, fertilizers etc.) increasing the Allowance cost per tonne of cement and therefore the Portland cement price.

### UK and Global Markets

The UK government is targeting 30 Mt CCS per year capacity by 2030. At £120/t CO<sub>2</sub>, this values the market in the short term at £3.6B. Globally, the CCS market is forecast to reach \$1000B by 2050.

## Business Development 3 (Business Planning)

The value chains for traditional CCS rely on having the infrastructure in place to transport and permanently sequester CO<sub>2</sub> emissions. The capex of this is a major barrier to entry as well as the energy requirement and operating costs.

Heidelberg Materials is constructing the first large scale EU cement CCS facility a 400 ktpa carbon capture facility at their cement plant in Brevik, Norway. This will capture about 50% of the CO<sub>2</sub> produced by the facility, and produce 600 ktpa of carbon neutral Portland cement. Branded as “evoZero”, Heidelberg Materials are intending to sell evoZero through any of their European cement plants. This represents a significant benefit since it can be sold in geographies where it offers the most value, and is able to command a premium price. A similar model could be used by a cement major implementing a Seratech facility in Europe.

### Direct Air Capture

Direct Air Capture (DAC) involves concentrating CO<sub>2</sub> from atmospheric concentrations of ~400 ppm to sufficiently high concentrations that it can be sequestered geologically, mineralised or used in the manufacture of other products, eg fuels.

DAC typically generates carbon offset credits which can be purchased by emitters or industries not suited to point source capture, such as aviation. Due to the increased cost of DAC and lack of alternatives for credit purchasers, DAC credits typically attract a higher price than ETS Allowances.

There are several approaches to DAC, but the majority involve a cyclic process in which CO<sub>2</sub> is captured chemically by a sorbent over a long period of time. That sorbent is then regenerated by heating which produces a much more concentrated stream of CO<sub>2</sub> that can be liquified for sequestration or utilisation. Typical sorbents include amines, metal oxide frameworks (MOFs), or alkali metal hydroxides (eg calcium or potassium hydroxide).

Frontier is an advance market commitment that seeks to prime the DAC market through the pre-purchase of carbon credits at inflated prices (\$500-1000 / t CO<sub>2</sub>).

As detailed in section 7.3, Seratech is currently exploring the applicability of the CCMU process to DAC (whether directly, or through partnerships). This would allow access to Frontier’s advanced purchasing, improve the potential of the technology in regions without an ETS (such as the USA, where DAC is more highly valued), and further improve the revenue / profitability of the process.

### Carbon Capture - Competition

- Carbon Capture and Storage (CCS) - Geological sequestration
  - Requires CO<sub>2</sub> to be concentrated to 100% and liquefied for transport. High operating cost of facility. Capital intensive to install infrastructure to transport CO<sub>2</sub> to sequestration sites – particularly for isolated facilities.
  - To date this is only economically feasible with large Government subsidies.

## Business Development 3 (Business Planning)

- There are multiple examples of CCS projects worldwide, but few in operation and those that are rarely perform as well as designed.
- Direct air capture
  - Requires large amounts of energy to concentrate CO<sub>2</sub> from atmospheric levels (400ppm) to a high enough concentration.
  - Still requires an end use – eg mineralisation, geological storage.
- Nature-based solutions
  - Low carbon density in terms of CO<sub>2</sub> sequestered per km<sup>2</sup>.
  - Once the CO<sub>2</sub> is stored in the trees / crops / algae etc it needs to be stored permanently (eg as biochar).
  - Low market confidence in the reliability of the solutions.
  - Often reversible over time.
- In-situ Mineralisation
  - CO<sub>2</sub> is sequestered in suitable geological formations without extraction.
  - Requires high concentration CO<sub>2</sub> at pressure or liquefied – energy intensive
  - Difficult to measure and verify total CO<sub>2</sub> sequestered, or monitor leakage
- Product Mineralisation
  - Many technologies rely on niche calcium-rich wastes that are not available at the Mt of Gt scale.
  - Silicate mineral based technologies are often energy intensive (operating at high temperature and pressure)
  - May require CO<sub>2</sub> to be purified or concentrated prior to sequestration.
  - Typically produced low value products, eg aggregates and fillers.
- Seratech
  - Can utilise 10% CO<sub>2</sub> from industrial flues, without the need to remove impurities
  - Relies on naturally abundant magnesium silicate minerals
  - Low energy process
  - No risk of CO<sub>2</sub> leakage from stable magnesium carbonate product

## Silica, Supplementary Cementitious Materials and Cement

### Cement

Concrete is the most widely consumed construction materials on the planet, due to its unique combination of low cost, global availability, ease of manufacture, and good structural performance and durability.

Portland Cement is the main binding ingredient in concrete, typically accounting for 10-15% weight, however, it is responsible for 90%+ of the CO<sub>2</sub> emissions of concrete.

The UK consumes 15 Mt of Portland cement and SCMs per year, a market valued at £2B. This produces 10 Mt CO<sub>2</sub>, costing a further £1.2B if full carbon taxation is enforced under the ETS. If the full cost of taxation was passed to the consumer, this would increase the price of cement from the current rate of £150/t to over £200/t by 2030. In the long-term we will target the global market, which is currently valued at \$330B with 8.4% forecast CAGR.

In recent years, the Portland cement price has increased rapidly as the cost of process CO<sub>2</sub> emissions are accounted for and the cost of electricity increases. The expectation is that the cement price will continue to increase in Europe and the UK as a CBAM will gradually remove the Free Allowances for cement (currently these are around 75% of the carbon emissions). This will result in the price of cement increasing from its current level of £150/t in 2023 to over £200/t by 2033. This has a positive impact on the revenues and the margins for the Seratech process.

### Supplementary Cementitious Materials

The low carbon Silica product from the Seratech process will primarily be sold for use as a supplementary cementitious material (SCM), replacing a proportion of the Portland cement in concrete. When combined with Portland cement made from a plant with the Seratech process absorbing its emissions then the resulting binder will offer a 94% reduction versus Portland cement.

It can be used as a direct, 1:1 replacement to other SCMs, such as fly ash (or pulverised fuel ash, PFA) or ground granulated blastfurnace slag (GGBS). These are the most commonly used SCMs in the UK and Europe, but face a decline in availability due to moves away from burning coal and producing iron in blast furnaces, from which they are respective by-products.

The GGBS market in the UK is around 3 Mtpa, in Europe 30 Mtpa and worldwide 350 Mtpa. As blast furnaces are replaced by electric arc furnaces the worldwide GGBS is expected to reduce to around 250 Mtpa. The recent announcement to close the Port Talbot blast furnaces by the end of 2024 will create a shortfall of 0.5 Mtpa of GGBS in the UK.

## Business Development 3 (Business Planning)

The global fly ash market is around 600 Mtpa with around 50% (for quality and logistics reasons) used as a cement replacement. This is also set to decline as burning coal for electricity diminishes – especially in Seratech's early target markets of the UK, EU and US.

The quality of SCMs can vary greatly, but typically replacing Portland cement in concrete with them decreases its compressive strength, particularly at early ages.

Historically in the UK GGBS was priced at 60 to 70% of the OPC price, as a way for steel manufacturers to generate revenue from a waste product. However, increased demand due to its lower carbon credentials has seen the price rise to around 90% of Portland cement. There is every expectation in the industry that GGBS prices will reach parity in the coming years and potentially command a premium price to Portland cement whilst it is the only viable route for projects to achieve low carbon concretes.

### Concrete

In the UK and the US, GGBS is sold separately to Portland cement to the ready-mix concrete producer who mixes the two at their plant, optimising the blend to suit their customer's requirements. In Europe, typically the cement producer manufactures a blend of the slag and the cement and sells this as a CEM II or a CEM III to the ready-mix concrete producer.

If the plant operator / licensee is a cement manufacturer, they will be able to use the Silica produced in the plant in their own downstream ready-mix concrete operations.

Either way the Silica can be sold as an alternative to or as an addition to GGBS. The customer will make additional margin from using Silica as an alternative to GGBS or Portland cement as well as improve the declared carbon in their products' Environment Product Declarations (EPDs).

GGBS is currently in short supply and oversold as construction companies and end users demand lower carbon concrete for their projects. This is a key driver in demand for alternatives. We do not envisage any problem selling all the Silica that the Seratech plants can produce in the markets that we will operate in.

### Low Carbon Concretes - Competition

- Supplementary Cementitious Materials
  - Replacing a proportion of the Portland cement in concrete with an alternative material, often a calcium-containing industrial waste.
  - Often this will be GGBS with fancy branding.
  - Other novel materials or blends are more scalable but limit CO<sub>2</sub> mitigation to ~50%, hence some carbon capture or offsetting is still required.
- Geopolymers / Alkali-activated cementitious materials (AACMs)

## Business Development 3 (Business Planning)

- AACMs are almost always GGBS mixed with an “activator” such as sodium hydroxide or silicate and use no Portland cement. The lack of GGBS availability is a significant barrier to their scalability.
- Other, more novel products are in development, such as AACMs made from calcined clay, but AACMs are not currently covered by Standards.
- CO<sub>2</sub>-cured concretes and aggregates
  - Concrete products are cured in CO<sub>2</sub> chambers, and set by carbonating. These products are unable to be used in ready-mix / in-situ concrete applications which make up the bulk of the market.
  - CO<sub>2</sub> is injected into wet concrete and is mineralised as the concrete sets. This is only able to reduced embodied CO<sub>2</sub> by ~5%.
  - CO<sub>2</sub> is injected into industrial wastes to produce aggregates
  - All of these approaches require relatively concentrated CO<sub>2</sub> streams which are costly and energy intensive to produce and can only replace a small percentage of the carbon emitted
- Bio cements
  - Uses a calcium carbonate-precipitating bacteria to produce concrete-like products.
  - Still requires a calcium source, which will be a niche industrial waste or produced by calcining limestone.
- Novel Processes and Products
  - Encompasses a whole range of approaches which are typically based on alternative binders and chemistries. Standards are likely to be the main barrier for these technologies. Some only be suitable for concrete products applications.
- Portland cement from alternative processes
- Seratech
  - Uses naturally abundant magnesium silicates as a feedstock, and other reagents are regenerated.
  - Carbon mineralisation can result in a carbon neutral cement.
  - Silica meets existing Standards

## Magnesium Carbonate and Construction Products

MagCarb is a low carbon binder that can replace Portland cement in a number of markets. Initially, the intention is to sell this into concrete product markets where standards are more flexible, and risk is lower. Three markets of particular interest are: concrete blocks, concrete bricks and boards. MagCarb is directly interchangeable with Portland cement without any changes to the manufacturer's process. Seratech will sell the MagCarb binder to existing manufacturers of these products, rather than manufacture itself.

### Concrete Block Markets

The global market for concrete blocks in 2021 was USD 350B and is projected to grow to USD 566B by 2029, at a CAGR of 6.3%. In the UK, we produce 75 M m<sup>2</sup> of concrete blocks per year, for use in domestic and commercial buildings, as well as major infrastructure projects. The majority of these are 7.3 MPa medium-dense grey blocks.

Block manufacturers consume around 1 Mt of Portland cement per year (£150M market value), with this representing around 50% of the total material costs. Manufacturing 1 t of concrete blocks produces 73 kg of CO<sub>2</sub>.

Current testing indicates about one third more MagCarb is required than Portland cement to achieve the desired strength (as specified by the standards for concrete blocks). A MagCarb block can be produced using exactly the same equipment and process as a conventional cement-based block. This ensures manufacturers do not need to make significant capital investments to use MagCarb and do not need to switch entirely to it - they can simultaneously produce lines of MagCarb blocks and conventional cement-based blocks.

Margins for block manufacturers are low and the pricing of MagCarb at a 40% discount relative to Portland cement results in a 10% reduction in raw material costs. This is a significant saving that offers an economic incentive to producers, as well as an environmental benefit of being able to sell a near zero carbon block. We expect the MagCarb blocks to have around 20% of the embodied carbon of existing grey blocks.

It is likely that as we improve the product and optimise the block mix designs, we will get closer to parity with cement and so there may be some potential to increase pricing of the MagCarb. As with the Silica, we have not assumed the block manufacturers will be able to charge a premium for the zero carbon blocks, however, it seems likely that they should.

### Brick Markets

The global market for bricks in 2022 was USD 1642.2B and is projected to grow to USD 2096.4B by 2030, at a CAGR of 3.1%. In the UK, we use 2.6 B clay-fired bricks per year, in a range of applications, with a total market value of £1.4B.

The majority of emissions associated with bricks comes from the firing process. Firing for 24 hours at over 1200°C in a gas kiln typically produces 240 kg CO<sub>2</sub> per tonne of bricks and costs £32 in energy.

The advantage of a MagCarb brick is that it does not require firing and can be cheaper to produce. The nature of the MagCarb binder means the mix design and production processes can be tailored to achieve an aesthetic similar to that of a clay-fired brick or reconstituted stone. Since MagCarb is white, the colour can also be easily modified through the addition of pigments.

There are numerous grades of bricks with different performance requirements, from façade materials to engineering bricks with compressive strengths of over 100 MPa. Initially, we will target façade and low-performance bricks, such as those for domestic applications. These also make up the majority of the market.

MagCarb bricks can also be made in existing brick factories, where they can be hand thrown, cast, pressed or extruded depending on the facilities and desired brick. However, they do not need to be kiln fired. As for blocks, manufacturers do not need to make significant capital investments to use MagCarb and do not need to switch entirely to it.

Raw material costs for MagCarb bricks may be slightly higher than conventional clay-fired ones, however the energy saving from eliminating the need for curing at over 1200°C means they can be produced cheaper than clay-fired ones.

As for blocks and Silica, no premium has been assumed for low carbon bricks. Due to their nature as a visible facing product, the bricks are, in reality, the most likely MagCarb product to be able to achieve a premium price, and there is precedent for this with some competitor products.

### **Block and Brick Competition**

Since many new sustainable alternatives to brick utilise a cement-like binder, they are essentially smaller dense concrete blocks. As such, competitors are dealt with together in this Section, and there is some overlap with technologies and companies mentioned in Section 3.3:

- Alternative cementitious binders
  - CO<sub>2</sub> cured bricks and blocks require specialist CO<sub>2</sub> chambers and a pure stream of concentrated CO<sub>2</sub> which is typically energy intensive to obtain.
  - Bio-based products are typically based on calcium carbonate precipitating bacteria. These require a calcium source which is often from decomposing limestone.
  - Lime-based binders are carbon intensive as they require the decomposition of limestone to produce, releasing CO<sub>2</sub> into the atmosphere.
- Alternative binders
  - Plastic based binders are able to use high quantities of recycled waste, but are low-performance and exhibit poor fire resistance.
  - Rammed earth bricks and blocks are only suitable for low performance applications. Since they are set by drying, they have poor water resistance and

should not be used for external walls.

- Natural materials
  - Hempcrete stores significant quantities of carbon (as organic material) in blocks. However, these products are typically low performance and lack durability.
  - Mycelium building materials are a new technology still in the early phases of development. Whilst some researchers are attempting to make blocks, early indicators of poor strength and durability means mycelium is likely to be limited to insulation products.
- Alternative firing
  - Hydrogen fired products remove the emissions associated from fossil fuel powered kilns. However, this approach requires good availability of green- (or at least blue-) hydrogen. It does not remove the energy (and associated cost) of firing bricks, and require capital intensive modifications to existing facilities.
- Reclaimed and recycled
  - Re-using bricks is an excellent way to minimise the need for virgin materials, however reclaimed and recycled products can vary substantially in quality, performance and availability, making this difficult to implement logistically.
- Seratech
  - MagCarb bricks and blocks are price competitive with incumbent products, can be produced using existing equipment and offer sufficient performance for the majority of applications.

### **Board Markets**

The global market for board products in 2023 was USD 26.7B and is projected to grow to USD 46.3B by 2033, at a CAGR of 5.7%. In the UK, we use 270M m<sup>2</sup> of board products each year. This is dominated by gypsum-based plasterboard.

Gypsum plasterboard production is an energy intensive process, with 1 m<sup>2</sup> of board typically having 3.2 kg embodied carbon arising through the dehydration and drying required. The end-of-life disposal of gypsum also has significant environmental impact, including sulfate leaching into landfills and the emissions of hydrogen sulfide gas.

A MagCarb alternative to a gypsum board can be manufactured in the same factories, using the same equipment but required less drying and, therefore energy to produce. MagCarb also offers better fire and moisture resistance, allowing it to directly compete with the premium plasterboard products.

Raw material costs for MagCarb boards may be slightly higher than gypsum plasterboard, however the reduction in energy required can result in price parity. Once again, no premium has been assumed for low carbon boards.

### Board Competition

- Alternative binders
  - Lime-based binders can be used for boards, as for blocks and bricks. Lime is carbon-intensive to produce.
  - MgO-based binders have similar drawbacks to lime. Typically, this is produced by decomposing naturally occurring magnesium carbonate, releasing CO<sub>2</sub> into the atmosphere. MgO may be produced from magnesium silicates (as in Seratech's process) or from seawater via electrolysis. However, existing approaches to these methods are energy intensive and prohibitively expensive.
  
- Natural materials
  - The incorporation of natural fibres or other plant waste can increase the amount of carbon sequestered within a board product, and may give a slight boost in structural and/or durability performance. However, these products still require a binder such as gypsum or lime whose production is carbon intensive.
  
- Seratech
  - A MagCarb board can be price competitive with existing gypsum products and made using the same equipment in existing factories. Fibres and other natural waste or other recycled materials can be incorporated to further improve the sustainability.
  -

# Licensee Business Model & Techno-Economic Analysis

## Target Licensees

## Business Development 3 (Business Planning)

A carbon dioxide emitter that would suit the Seratech process would most likely be in the UK or EU ETS. The plant would be sized to cover the emissions which the emitter needs to buy Allowances to cover. The CO<sub>2</sub> used in the Seratech process would not be emitted and therefore would not need to have Allowances purchased to cover it, saving the emitter money.

A prospective licensee has two alternatives to the Seratech process:

- To purchase Emissions Allowances in the Trading Scheme.
- “Traditional” CCS, with geological sequestration.

Seratech offers the best value of these, as indicated in Table 4.1 below, summarising the costs associated per tonne of CO<sub>2</sub> emitted or sequestered. Note: this uses the price scenario for 2030 as set out in the next sections and assumes the product price increases to cover the cost of carbon.

Table 4.1 – A summary of the associated costs of different approaches to emissions mitigation.

£	Purchase Allowances on the UK ETS	“Traditional” CCS with geological sequestration	Seratech
Costs	Allowance 105	Opex 120	Opex 236 License Fee 45
Avoided Costs	CO <sub>2</sub> emitted 105	CO <sub>2</sub> emitted 90*	CO <sub>2</sub> emitted 90*
Revenue	-	-	Products 426
EBITDA	0	-30	+235

\* assumes geological sequestration is the same efficiency as Seratech (86%, ie sequestering 1t CO<sub>2</sub> produces 0.14t)

The licensee does not necessarily have to be a cement company. Indeed, there are many smaller emitters who would most likely be a better match for Seratech, especially in the early years of licensing. For example, brick manufacturers typically emit around 50 ktpa of CO<sub>2</sub> per factory, a similar amount is emitted by plasterboard manufacturers per factory. In the UK there are around ten brick factories and ten plasterboard factories of this size. Other potential CO<sub>2</sub> sources are gas-fired or biomass power stations, fertiliser manufacturers, glass factories, and many other large industrial emitters within the ETS.

## Assumptions for Techno-Economic Analysis

### CO2 Pricing and Free Allowances

We have assumed that the CO2 price in the UK and EU trading schemes will increase over time as fewer Allowances are available. For simplicity, the following modelling assumes the UK and EU ETS prices are the same and this is given in GBP.

In line with Government projections, we have assumed that the ETS price is established at £85/t in 2026 (once the markets and trading systems are established) and grows steadily at £5/t per year until it reaches £120/t in 2033. This plateau reflects the expected full cost of CCS (ie the revenue generated from one Allowance, spent by the government, achieves 1 t of carbon removal and resulting in a net zero economy).

At the same time the CBAM will reduce free allowances as shown in the orange line below. The combination of increasing CO2 price and reducing free allowances increases the CO2 cost per tonne of product. This is summarised in Figure 4.2.

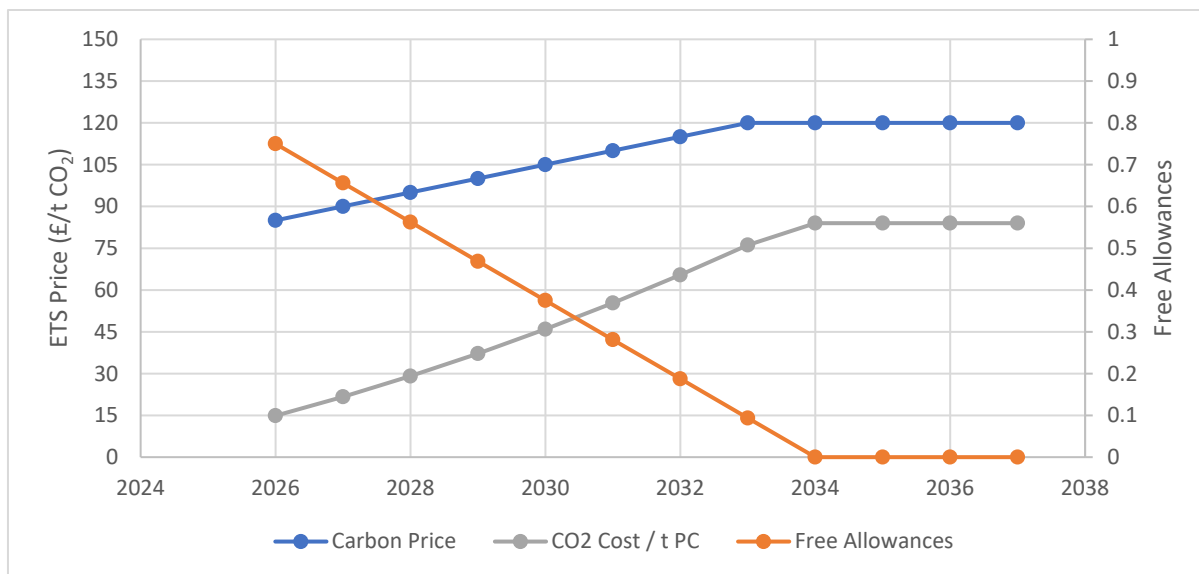


Figure 4.2 – Assumed ETS price and average Free Allowances over time.

## Other Assumptions

Table 4.4 – A summary of other assumptions used in subsequent techno-economic analysis.

Variable	Assumption	Reasoning
Price of Olivine (including shipping, not grinding)	£50 / t	A conservative assumption, based on an initial price from Grecian Magnesite of USD19 / t which is exclusive of shipping and grinding.
Inflation	0%	Inflation is ignored for the purpose of this analysis and all costs are in 2024 £s

## Techno-Economic Analysis

The gross margin at £320/t of CO<sub>2</sub> absorbed is 62% of revenue before the fixed costs of operating the plant and the finance costs of building the plant. Our estimates indicate that this would provide sufficient margin for the customer to invest profitably and provide a significantly better return than current and future CCS estimates.

Table 4.6 – Financial summary for a 2030 scenario.

Gross Margin	£ 320.43 / t CO <sub>2</sub> (62.0%)
EBITDA	£ 235.31 /t CO <sub>2</sub> (45.6%)

A Seratech Licensee will be able to invest in the Seratech process, allowing them to directly sequester all of their Scope 1 emissions, resulting in being able to produce their core product with very low embodied carbon. In addition, they will be able to sell ultra-low carbon MagCarb and Silica to decarbonise ready-mix concrete and concrete products, cover the cost of capital, and make significant profit.

This compares with CCS where currently no project in Europe can proceed without significant EU or government subsidies to cover the cost of capital, let alone make a profit beyond that.

## Business Development and Growth

With the ultimate goal of licensing Seratech’s CCMU technologies to industrial emitters, allowing them to sequester their own emissions, it is vital to first demonstrate the technology at a relevant industrial scale. This ensures that emitters are willing to invest the capital required

## Business Development 3 (Business Planning)

for their own facilities. This section lays out a route to scaling the technology, building confidence in both the process and SCM product, and demonstrating market demand.

### Phase 1 – Research and Development (2021 –2024)

#### Key Activities

- Process and Product validation and optimisation
- Building key partnerships within relevant value chains
- Design of Pilot facility
- Raise £3.7M Seed

### Phase 2 – Pilot (2025)

#### Key Activities

- Process validation at Pilot scale
- Publication of further patents to strength IP
- Demonstration projects for Silica and MagCarb products
- Certification of Silica to BS 8615 / BS 8500
- Certification of MagCarb block to EN 771-3
- Design of Industrial Pilot
- Secure partnership for Industrial Pilot
- Continued R&D for product diversification
- Raise £15-20m Series A

### Phase 3 – Industrial Pilot (2026 – 2027)

#### Key Activities

- Process validation at industrially relevant scale
- Further patents to strengthen IP
- Agreement of first licensing deal
- Design of first licensed plant
- Continued R&D for product diversification
- Revenue generating sales of products and income from CO2

## Phase 4 – Licensing and Scale-Up (from 2027)

### Key Activities

- Process validation at industrially relevant scale
- Agreement of first licensing deal
- Design of first licensed plant
- Continued R&D for product diversification

# 8 Team

## 8.1 Board of Directors

### **Sam Draper**

CEO & Co-founder

Sam Draper studied Engineering at the University of Cambridge, before moving to Imperial College London in 2017 to undertake a PhD in the field of low carbon cement chemistry. During this time, he co-founded Seratech with Barney Shanks.

In his current role as CEO of Seratech, Sam leads the business development as the company looks to scale their solution, working closely with numerous parties throughout the cement and concrete value chains. Sam regularly gives presentations and takes part in panel discussions to increase awareness of the challenges facing the construction industry and potential solutions.

### **Barney Shanks**

CTO & Co-founder

Barney Shanks studied Chemistry at the University of Surrey, before moving to Imperial College London in 2018 to undertake a PhD exploring the processing of magnesium silicate mineral into cementitious materials. During this time, he co-founded Seratech with Sam Draper.

In his current role as CTO of Seratech, Barney leads the technical development and optimisation of new products and processes, and ensure these fit within existing markets to be commercially viable. He manages the company's IP portfolio and pipeline, and engagement with key research collaborators, such as Imperial College London.

## Business Development 3 (Business Planning)

Dr Mike Cook FREng

Chairman

Mike Cook spent 45 years in the construction industry successfully delivering large innovative engineering design projects to tight commercial time schedules. He is a Fellow of the Royal Academy of Engineering, won the prestigious Institution of Structural Engineers' Gold Medal in 2020 and is a former Vice President of the Institution.

In his role at Seratech, Mike ensures that the business and technology is highly visible and well understood in the relevant industry sectors, and that potential partners and investors are keen to engage in subsequent commercialisation. He will also provide strong links into the professional institutions and consulting practices so that the future specifiers of newly available materials are prepared to take up the opportunities for low carbon products.

## Technical Team

### **Caitlin Howe**

Technical Director

Caitlin Howe studied Materials Science at the University of Cambridge, before moving to Imperial College London in 2020 to undertake a PhD in the field of low carbon cement chemistry. During this time, she began working with Seratech.

In her current role as Technical Director of Seratech, Caitlin leads the development and optimisation of Seratech's magnesium carbonate products and technologies.

### **Dr Usama Mohamed**

Usama Mohamed completed his PhD at the University of Sheffield within the Energy 2050 group in assessing the techno-economic feasibility of scaling up novel power generation technology via process modelling. Prior to his PhD, he obtained an MEng in Chemical Engineering focusing his final year research project on carbon mineralisation. After graduation, he worked on a collaborative project between the University of Sheffield and Exawatt as an Industrial Research Fellow, conducting techno-economic assessments in scaling up battery cathode active material manufacturing.

Usama is responsible for transforming the current lab-scale process, into a specified plant that can operate at an industrial scale of >1 Mt CO<sub>2</sub> sequestered per year.

### **Dr Noël Djobo**

Since obtaining his PhD in Chemistry from the University of Yaoundé, Noël has worked on developing a range of cement-based materials including those derived for clays and other waste materials.

Through the DESNZ project, Noël is responsible for optimising the silica SCM for use in concrete, and designing and testing appropriate concrete mixes for a range of real-world applications.

### **Prof Hong Wong**

Hong Wong is Professor of Concrete Materials at Imperial College London. He is an expert in the microstructure and durability of cementitious materials, with 20 years' experience developing innovative materials including low carbon concretes. He has a strong international profile and holds leadership positions in major industry-led research consortiums including Nanocem and Innovandi.

In his role as a Technical Advisor, Hong contributes to the development of Seratech's concrete and magnesium carbonate products to ensure they are based on sound science before being trialled at scale. He also manages the DESNZ project and co-ordinates research activities being undertaken within Imperial College London.

### **Prof Chris Cheeseman**

Chris Cheeseman is Professor of Materials Resources Engineering, Head of the Materials Section and Director of the Centre for Infrastructure Materials at Imperial College London. He has published extensively in the fields of sustainable materials, resource efficiency and circular economy. He has led numerous successful and diverse industry linked research associated with resource efficiency and development of low-carbon materials.

In his role as a Technical Advisor, Chris contributes to the development and optimisation of Seratech's CCMU process. He also manages the DESNZ project and co-ordinates research activities being undertaken within Imperial College London.

## **Commercial Team**

# SWOT Analysis

## Strengths

- Seratech has a strong founding team, with experts in the fields of science, engineering, construction materials and business. The technology stems from research at a high-quality academic institution.
- The simple processes require minimal energy to run and chemical reagents are regenerated, ensuring minimal consumption and production of harmful wastes.
- The process produces large quantities of two valuable cementitious materials, giving strong outcomes of the techno-economic analysis and high margins.
- The cementitious products are compliant with existing standards and regulations, minimising the barriers to market entry.
- The technology has been comprehensively tested at lab scale, with the products demonstrating excellent performance in relevant environments (TRL5/6).

## Weaknesses (and responses)

- The ultimate impact of the technology is limited by the size of available markets and uses for MagCarb. To combat this, Seratech is actively developing a range of MagCarb products which fit into high volume markets.
- Although abundant, olivine currently has few commercial uses, meaning it is not extracted in huge quantities. To minimise the impact of this, Seratech will grow its business in appropriate geographies, with sufficient supply, and is exploring the use of waste materials, such as mine tailings, as an alternative input to the process.
- Seratech does not currently have a commercial team to engage with potential customers and build licensing deals. It is anticipated that we will begin to build this capacity in future funding rounds, starting with a Chief Commercial Officer in late 2024, ahead of a large team after Series A.

## Opportunities

- There is growing demand for low-cost CCS technologies, with Government support in the form of grants, a functioning ETS and CBAM
- There is growing and immediate demand from contractors and building users for decarbonised and sustainable concrete, as evidenced by the industry's commitments to initiatives such as ConcreteZero.
- Through Seratech's core process, we are actively developing new opportunities, such as direct air capture and alternative cementitious materials and markets.

## Business Development 3 (Business Planning)

### Threats (and responses)

- Competition in the area of low carbon cement and concrete has been growing rapidly in the past five years and is likely to accelerate as the potential rewards are significant. However, this increased activity has helped build awareness and interest in the field, and Seratech's economic incentives, and that its products are compliant with existing standards are key USPs.
- The cement industry has historically been reluctant to adopt major innovation. However, Seratech's approach is complementary to the standard process and this could be seen as a USP of our technology. Seratech will be serving the cement industry (and other emitters) to become more resilient and profitable.
- Our licensing model is not well established and could face difficulty or be undermined by fraudulent misuse etc. Protecting Seratech's IP will be a business priority, and the business retains the option to construct and operate facilities itself - although this will slow growth.

---

If you need a version of this document in a more accessible format, please email [alt.formats@energysecurity.gov.uk](mailto:alt.formats@energysecurity.gov.uk). Please tell us what format you need. It will help us if you say what assistive technology you use.