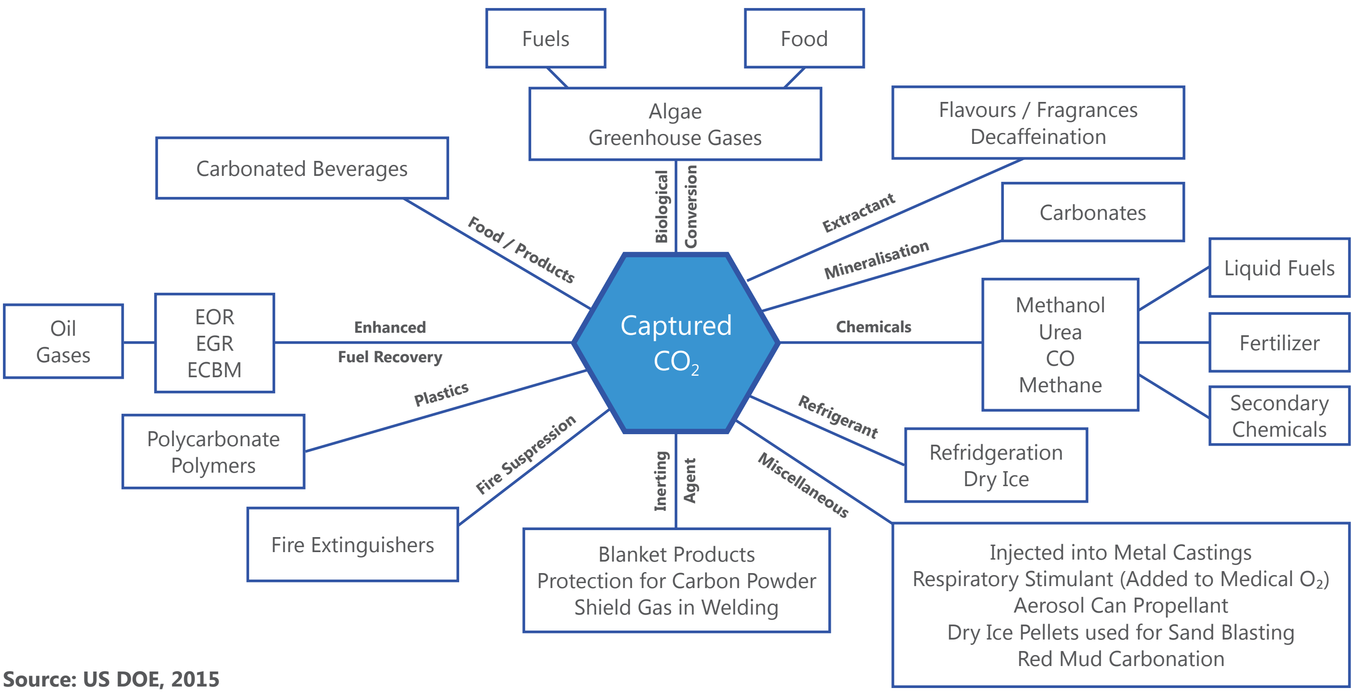
State-of-the-art

Carbon Dioxide Capture and Utilisation CCU. Putting the U into CCUS

What is CCU and why is it important

Most people have heard of CCS (Carbon Capture and Storage), where it is anticipated that millions of tonnes of Carbon Dioxide will be captured from large scale CO_2 emitters such as steel plants, cement works or big chemical plants and pumped into geological storage such as the oil fields of the North Sea. This is the most important part of most governments' strategies to lower their carbon emissions to reach net zero by 2050. In the UK, there have been a couple of false starts, but the government are now investing large sums of money in the development of industrial clusters than can build the necessary infrastructure to be able to send their CO_2 out into geological storage. However, it is not happening yet and is at least 5 if not 10 years away.

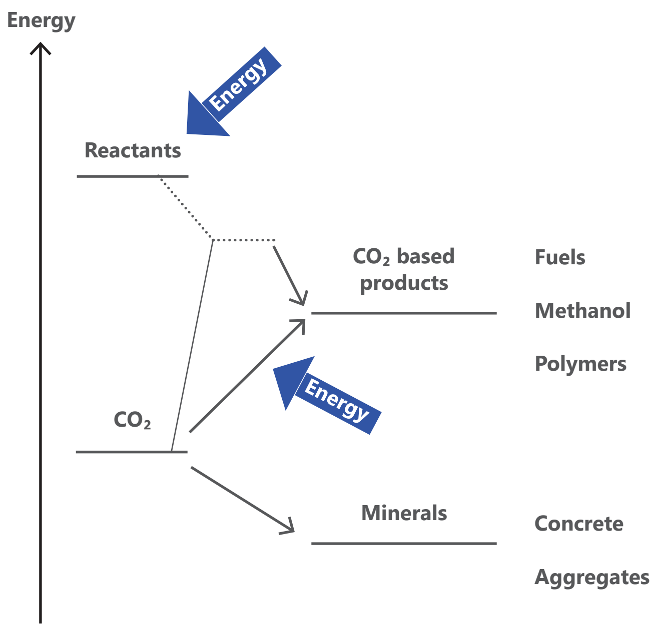
In contrast, CO_2 has been captured and used, for many years, in a variety of industrial applications such as in fire extinguishers, in drinks or for refrigeration, and more recently a wide variety of uses or utilisation technologies have been developed to replace products that in the past have been manufactured from fossil fuels or other natural resources, as shown below.



Source: US DOE, 2015

These products have value, the technologies are commercially sustainable and CO_2 from isolated sources (not near a cluster) can be used.

Carbon8 Systems' Accelerated Carbonation Technology (ACT) falls into the process known as mineralisation, where the CO_2 is converted into carbonates. Mineralisation has a distinct advantage over other utilisation technologies in that the conversion from $CO_2$2 to carbonates is an exothermic process – it emits energy rather then needing energy to perform the transformation. Other conversion technologies producing fuels, or other precursor chemicals for plastics etc require energy which must be in the form of renewable energy to ensure that the processes are carbon neutral or negative.



There are at least fourteen companies worldwide that have mineralisation technologies that are at pilot if not fully commercial scale. Of these the Canadian company Carboncure is probably the most well-known and is making good commercial progress. They are injecting CO_2 into concrete as it is poured, which causes small crystals of carbonate to form which in turn promote the hydraulic hardening of the concrete so that some CO_2 is permanently captured and less cement is required in the concrete. There are at least three companies who are precipitating carbonates from alkaline liquids or brines (Calera and Blue Planet in the USA, Carboclave in Canada and the Carbon Capture Machine in the UK). These precipitates can be used as light weight aggregates (Blue planet), as supplementary cementitious materials in cement or as fillers in a variety of industrial applications.

Mineralisation technologies require a source of calcium or magnesium or sometimes aluminium ions to react with the CO_2. These can be from natural sources such as in ultrabasic rocks (Green minerals, in The Netherlands), basalts (Carbofix, in Iceland) or magnesium rich rocks (Cambridge Carbon Capture, in the UK).

Alternatively, many industrial residues, particularly those from thermal processes such as cement manufacture, energy from waste plants or steel manufacture have the chemistry that make them reactive to CO_2.

At least two companies are carbonating steel slags to make blocks for construction: Orbix in Belgium and Carbicrete in Canada. Alcoa in Australia have been treating Red Mud from Aluminium smelting via carbonation and CCm research have been using carbonation of ashes to coat waste fibres from anaerobic digestion to produce a fertiliser.

Carbon8 Systems specialises in the treatment of industrial residues and has been looking at the potential for CO_2 capture in residues available in Europe and globally. As shown in the table below given the availability of suitable residues there is the potential to capture 28 M tonnes of CO_2 per year just in Europe. Some of these residues have other uses but C8S believes it not unreasonable to suggest that by rolling out our technology it would be feasible to capture over 1 Mt of CO_2 per year.

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Key industry	Waste Streams	Global volume (million tonnes)	European volume (million tonnes)	Current average cost of disposal (£ / tonnes)	Total European Market size (£ million)	Tonnes CO_2 captured in Europe (million tonnes)
EfW	APCr, Fly Ash, Bottom Ash	75	45	120	5,400	4.41
Cement	Cement Bypass Dust (CBPD) Cement Kiln Dust (CKD)	410	21	50	1,086	4.78
Steel	Steel Slag, Stainless Steel Slag, EAF Dust	507	21	50	1,086	4.78
Biomass	APCr, Fly Ash, Bottom Ash	70	35	60	2,106	5.63
Paper & Pulp	APCr, Fly Ash, Bottom Ash	45	12	60	729	1.94
TOTAL		**1,105**	**177**		**12,493**	**28.18**

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