CCUS is boosting corporate profits even though many schemes could actually result in more emissions

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*This Geoengineering Map Update on **Carbon Capture Use and Storage** technologies summarises the latest developments on the Geoengineering Monitor Map, highlighting new trends for civil society and climate justice movements to follow in their efforts to oppose geoengineering globally. See here for other recent map updates, and here for a list of acronyms and abbreviations used in this update. This update is Part 2 of a three-part update on CCS, CCUS and DAC (coming soon). It was researched and written by **Anja Chalmin**, and published with the support of the Geoengineering Monitor team.*

In this update:

1. Critical developments in CCUS covered in this Geoengineering Map Update

- The construction and e-fuels industries are currently dominating developments involving Carbon Capture Use and Storage (CCUS), with other polluting industries such as steel, energy, and chemicals also increasingly turning their attention to CCUS in order to address their climate impacts.
- Neustark AG in Switzerland has signed a partnership with the world's largest cement producer to inject crushed demolition concrete with CO_2 to create "negative emissions", but a flawed Life Cycle Assessment (LCA) undertaken by the company highlights how the process they have developed could result in even more emissions.
- Iceland-based e-fuels company Carbon Recycling International (CRI) has raised millions towards a CCUS project that produces synthetic fuel (synfuel) using captured CO_2 and hydrogen, but claims that the process can lead to the "*wholesale elimination of CO_2 emitted direct to the atmosphere*" prove to be deeply misleading.
- E-fuels release the captured CO_2 back into the atmosphere as soon as they are used, and the energy-intensive processes of capturing the CO_2 and producing the synfuel, and the long transport distances involved, mean that they cannot be considered carbon-neutral.
- Their huge energy requirement makes e-fuels highly inefficient – with the same total energy input from

renewable sources, an electric car can travel up to five or six times further than a combustion engine running on e-fuels.
- Numerous companies are already making money by selling carbon credits generated through CCUS projects, even though they may be doing more harm than good in terms of their climate impact.
- Self-proclaimed commercial-scale flagship CCUS projects are still only able to capture and process negligible amounts of CO_2, and their implementation is often delayed significantly, despite the large investments that are being made into them.

2. Neustark AG makes bold claims about its CCUS projects, but they don't stand up to scrutiny

The construction sector produces more CO_2 than global aviation, with concrete production alone responsible for 8 % of global CO2 emissions. Global demand for cement is constantly growing, and some companies in the building trade are looking to improve their carbon footprints by locking CO_2 into building materials. The theory is that CO_2 can be captured from industrial processes and then injected into crushed waste concrete, which turns it into rock, and then the enriched concrete granules can be used in new construction projects.

The Swiss company Neustark AG is pioneering the process of mineralising captured CO_2 in granulated demolition concrete, and the company is already selling carbon credits to companies such as Microsoft, UBS, and Verdane. Neustark AG was founded by Valentin Gutknecht and Johannes Tiefenthaler as a spin-off from ETH Zurich, the Swiss Federal Institute of Technology. Its CCUS technique involves crushing demolition concrete into granules and exposing it to CO_2 in a closed container, which triggers the mineralisation process. According to Neustark, one tonne of demolished concrete can mineralise about 10 kg of CO_2.

Neustark is currently capturing CO_2 at Swiss biogas producer Ara Region Bern AG, and a second CO_2 capture site was constructed at a biogas plant in Germany in 2023, although the technology being used to capture CO_2 has not yet been publicly disclosed. In Germany, the captured, cooled, cleaned, and liquefied CO_2 is trucked some 200 km to a recycling company in Berlin for mineralisation in demolished concrete.

In September 2023, the Holcim Group, the world's largest producer of cement and building materials, invested in and entered into a strategic cooperation agreement with Neustark AG, and intends to deploy Neustark's technology worldwide. A mobile Neustark plant has been in operation at a Holcim site in Oberdorf, Switzerland since 2023, and the CO_2 is transported to this site by truck over a distance of around 120 km.

A Life Cycle Analysis (LCA) of Neustark's CCUS process was recently published in the *Frontiers in Climate* journal by Tiefenthaler, who was listed as the article's lead author. The article claims that the process mineralises more CO_2 than it releases, resulting in "negative emissions". However, the LCA was flawed, and for the following reasons it is more likely that the process actually emits more CO_2 to the atmosphere than it can mineralise:

- The LCA only starts considering emissions from the point at which the captured CO_2 is liquefied, and does not include the capture process or the subsequent cooling and cleaning of the CO_2. All forms of CO_2 capture require very large amounts of energy, and in fact CO_2 capture is the most energy-intensive part of the CC(U)S process, primarily due to the fact that CO_2 is an inert (non-reactive) gas.
- The LCA describes transport distance as being one of the most important factors influencing emissions intensity, and assumes a transport distance of 10 km between the CO_2 capture and the mineralisation sites. However, this hypothetical transport distance is significantly exceeded in Neustark's existing projects, meaning that the LCA substantially underestimates emissions related to transport.
- The research results published in the LCA show that smaller granules of crushed concrete can mineralise more CO_2 than larger ones, because their surface area and therefore the area of contact between the concrete and CO_2 is larger. The energy required to crush the demolished concrete increases with the degree of crushing, so if smaller granules are required to enhance the mineralisation process, additional energy consumption will be necessary. This was not factored into the LCA, and the degree to which the demolished concrete needs to be crushed to be recyclable remains unclear.
- Additional uncertainties include the transferability of the laboratory results to the real world, since field trials

have only been modelled so far. Also, the composition of demolition concrete has only been studied in the Swiss context, and the process is not automatically transferable to other parts of the world, for example due to different raw material availability and quality requirements.

850 million tonnes of construction and demolition waste ends up in landfill each year in the EU, and efforts should focus on reducing this waste first, and recycling it only if creating the waste is unavoidable. Whether Neustark AG's approach can reduce the carbon footprint of the construction sector is highly doubtful and, on top of this, numerous companies have already received millions in funding to mineralise CO_2 in building materials but have failed to do so or have yet to deliver, including Blue Planet Systems, Calera Cement, Novacem, and Solidia Technologies.

3. Other recent updates on CCUS in the construction sector

Canada – Carbon Upcycling Technologies (CUT): CUT aims to use captured CO_2 in consumer products, including cement. The company US$ 26 million in 2023 to support its planned CCUS projects, including a project at the CRH Ventures Mississauga cement plant in Canada, and at the CEMEX Rugby cement plant in the UK. In addition, Emission Reduction Alberta awarded CUT CAD$ 4.4 million for an Alberta-based R&D project which will use a combination of fly ash, CO_2, and other products to replace cement in concrete. The project will involve partnering with two CO_2 capture and cement production facilities in Alberta, owned by Burnco Rock products Ltd. and Lafarge Canada.

Germany – Holcim Beckum cement plant: In 2023, Holcim, ThyssenKrupp Uhde, and the Technical University of Berlin began testing an amine-based CO_2 capture technology on a small-scale at the Beckum cement plant. The project is funded by the German Government.

India – Dalmia Cement project: In 2019, Indian cement maker Dalmia Cement Ltd., a subsidiary of Dalmia Bharat Ltd., announced plans to build a CO_2 capture plant at its Ariyalur cement plant in Tamil Nadu and signed an MoU with Carbon Clean Solutions Ltd., a UK-based CO_2 capture technology developer. No visible progress has been made on the project, four years since it was announced.

Spain – Holcim Carboneras cement plant: A planned CO_2 capture facility at the Carboneras cement plant was expected to be operational in 2022, but Holcim delayed its commissioning first until early 2023, and subsequently to 2028/2029.

Switzerland, Iceland – DemoUpCARMA and DemoUpStorage: The DemoUpCARMA and DemoUpStorage R&D partner projects are led by ETH Zurich in collaboration with around 25 partners from industry and academia. Many of the participating companies have a commercial interest in CO_2 capture and storage as they have energy-intensive business models, or are able to transport captured CO_2. DemoUpCARMA aims to demonstrate CO_2 capture at a Swiss biogas plant and inject the captured CO_2 into recycled concrete (CCUS) in Switzerland or into geological formations (CCS) in Iceland. Transporting the CO_2 to Iceland involves a journey of over 3,000 km by truck, train, and ship, requiring CO_2 containers to be loaded and unloaded numerous times. At its destination, the Carbfix site in Helguvík, southwest Iceland, the captured CO_2 is mixed with seawater and injected underground into a geological formation for mineralisation. DemoUpStorage aims to monitor the injection processes there and assess its potential to be scaled-up.

USA – Blue Planet Systems: Blue Planet aims to replace mined natural limestone, a key component of cement, with manufactured synthetic limestone ($CaCO_3$), using captured CO_2 as a feedstock for the process. Blue Planet was founded in 2012 and hoped to open its first commercial production site in 2020, but for unknown reasons this plan has not been realised. Blue Planet's subsidiary, San Francisco Bay Aggregates, announced the construction of a pilot plant in 2021, but to date there is no evidence that it has progressed beyond the design and feasibility stage, despite attracting a large number of investors. Since 2023, the company has been participating in a US-DOE-funded feasibility study for a DAC hub in the Pacific Northwest region of the US.

USA – Solidia Technologies™: Solidia is a Rutgers University spin-off and claims to have developed a process that mineralises CO_2 as concrete hardens. In October 2023, Solidia announced plans to sell carbon credits in cooperation with 3Degrees, and to establish a pilot-scale cement production facility in Texas in 2024. With the new plant Solidia expects to increase its production capacity of cement-like materials 25-fold to approximately 360 tonnes per year. Despite being in existence for 15 years and having received millions of dollars in funding, the company is still in its pilot phase. The company describes itself as a "*leading provider of decarbonization technology*", although once the pilot plant is commissioned it will only mineralise 0.07 million tonnes of CO_2 per year.

4. CCUS in e-fuel production: No evidence that carbon can be retained over meaningful timescales

CO_2 can be used as a feedstock for fuel production, whereby captured CO_2 is combined with H_2 to produce synthetic fuels. However, the whole process, including CO_2 capture, H_2 production, processing, and synthesis requires significant amounts of energy. The fuel produced is usually consumed in the short or medium term, when the captured CO_2 is released back into the atmosphere. Consequently, this CCUS process should not be considered as a CO_2 storage solution, but rather as a source of additional CO_2 emissions. On top of this, e-fuels release similar levels of toxic air pollution as conventional fuels when they are burned.

Icelandic company Carbon Recycling International (CRI), devised an Emissions-to-Liquids™ (ETL) technology to produce methanol around two decades ago, and has been trying to develop the technique since. The process is very energy-intensive, and on top of the electricity required to produce H_2, the CO_2 needs to be captured, compressed, and transported, and then both components combined in a distillation process.

In 2023, CRI raised US$ 30 million from new shareholders, including fossil energy company Equinor Ventures and insurance company Sjóvá, and was also awarded US$ 350,000 from the Icelandic Technology Development Fund to develop its ETL technology. CRI's work on ETL has also been supported by several multi-million Euro EU-funded research projects, including FReSMe, MefCO2, and CirclEnergy, including research at a Swedish test site.

According to CRI, the technology is "*being implemented at [an] industrial-scale*", but despite substantial funding and R&D spanning almost 20 years, only small quantities of methanol are being produced. For example, 4,000 tonnes have been produced at CRI's George Olah plant in Iceland, and 0.1 million tonnes at the Shunli plant in China. In September 2023, the Sailboat plant in eastern China came online with a production capacity of another 0.1 million tonnes of methanol per year, and CRI has two more production sites in the pipeline: The Finnfjord plant in Norway, which is expected to produce 1,000 tonnes of methanol per year, and a joint project with Dastur Energy Pvt Ltd. in India.

By capturing and reusing CO_2, CRI promises the "*wholesale elimination of CO_2 emitted direct to the atmosphere*". However, this cannot possibly be achieved due to the fact that the captured CO_2 is returned to the atmosphere as soon as the fuel is used, via a very energy-intensive detour.

5. Other recent updates on CCUS in fuel production

Australia – HIF Asia-Pacific Pty Ltd.: The Australian subsidiary of Highly Innovative Fuels (HIF) Global has announced plans to develop a synfuel production facility in north-west Tasmania, Australia, and has applied to the Tasmanian Environment Protection Authority (EPA) for approval, which was targeted for mid-2023, but the EPA's deliberations are ongoing. HIF plans to burn 0.35 million tonnes of forest residues per year at the site, capture CO_2 from the flue gas, and feed it into a methanol synthesis process, after which it will be trucked to a port on Tasmania's north coast for export. In 2023, HIF Global engaged Technip Energies to commence the plant design process and announced plans to develop additional synfuels projects in the Asia-Pacific region.

Chile – HIF Haru Oni & Cabo Negro projects: In November 2023 HIF announced "*the beginning of its commercial exports of carbon-neutral eFuels to Europe*" from its Haru Oni project, after delivery of 24,000 litres to Porsche in the UK. HIF has also recently announced plans to test a Mosaic Materials DAC prototype at its project in Chile, which is expected to be operational in 2024.

In October 2023 HIF Global announced plans for a second synfuel project in the Magallanes region in Chile, located in the Cabo Negro industrial complex. The US$ 830 million project is expected to produce 0.17 million tonnes of methanol per year, which HIF aims to turn into "*carbon neutral*" synfuel.

Chile – AMER project: The Antofagasta Mining Energy Renewable (AMER) project is a feasibility study proposed by CO_2 capture technology developer Air Liquide, and it is has received US$ 11.8 million from the Chilean Ministry of Economy. The project aims to produce 60,000 tonnes of methanol per year from captured CO_2 and green H_2, and is expected to be operational by 2025.

India – Breathe Applied Sciences Pvt. Ltd.: The company's objective is to develop and commercialise a process which converts CO_2 captured from coal and natural gas power plants into methanol and other fuels. The company was founded in 2016 and, as of November 2023, had processed 1,000 tonnes of captured CO2.

India- NTPC Vindhyachal CCUS: This CCUS pilot project is linked to a 500 MW coal-fired unit at India's largest power plant, and is producing methanol from H_2 and captured CO_2. In 2023, the Indian Ministry of Power described the methanol produced as "green methanol". However, green methanol is produced using renewable energy, and methanol produced from coal is referred to as brown methanol, which has an emissions impact "*worse than that of diesel*" according to an industry source.

India – Panipat Refinery CCUS: At this Indian Oil Corporation Ltd. site, a CCUS project was due to come on stream in 2019, producing 40 million litres of ethanol per year from captured CO_2. So far only a small-scale plant has been completed, capturing up to 3.6 tonnes of CO_2 per year.

Uruguay – HIF Uruguay: In June 2023, HIF Global announced plans for a new methanol and synfuel production facility in the city of Paysandú, Uruguay. Construction is expected to start in 2025. At this site, HIF aims to produce 256 million litres of synfuel annually using captured CO_2. The exact location of the production facility, the origin of the CO_2, and the source of the energy that will be used in the process have not yet been publicly announced.

USA – HIF USA: HIF Global's original goal was to capture approximately six million tonnes of CO_2 annually at its site in Houston, Texas, but in 2023 this was reduced to two million tonnes. HIF USA is considered by the company to be "*The first large commercial scale eFuels facility in the world*", and aims to produce e-fuels by synthesising CO_2 captured from oil and gas infrastructure and H_2 produced using wind energy.

6. CCUS developments in other sectors

CCUS & biomass: A new study in the journal Nature Climate Change suggests that CO_2 emissions from growing biomass for CCUS projects, such as synfuel production, could be as high or higher than those from burning fossil fuels. Deforestation for biomass plantations also causes significant CO2 emissions through land-use change.

Germany – Carbon CO_2ncepts GmbH: Since 2023, the company has been participating in the "H2-Reallabor Burghausen/ChemDelta Bavaria" project, which includes the development and demonstration of biogas production in combination with membrane-based CO_2 capture. The captured CO_2 will be liquefied and transported to the ChemDelta Bavaria chemical park around 200 km away. The project is funded by the German Federal Ministry of Education and Research (BMBF).

Germany – Landwärme GmbH: The company operates and builds biogas plants that use biomass such as food waste and biogenic waste from industry and commerce as a feedstock. The gasification process produces a mixture of methane and CO_2, and in order to use the methane as biogas, the CO_2 contained needs to be separated from the methane, and is normally released into the atmosphere. Landwärme is now looking to capture and sell the CO_2, and it expects significant revenue generation from selling carbon credits. According to Landwärme, the concept could be particularly lucrative for biogas plants as the CO_2 has to be removed from the raw biogas anyway.

India – Angul CCUS: Jindal Steel & Power Ltd. (JSPL) is capturing CO_2 at its coal gasification plant in Angul, India , and exploring using it in the production of ethanol, methanol, soda ash, and urea. According to a report published by the National Institution for Transforming India, most of the captured CO_2 is currently being released back into the atmosphere.

India – CC(U)S research centres: The Government of India has established two "National Centres of Excellence in Carbon Capture and Utilisation" at the Indian Institute of Technology Bombay, and the Jawaharlal Nehru Centre for Advanced Scientific Research in Bengaluru, which were officially inaugurated in 2023. The centres are expected to accelerate R&D efforts, serve as hubs for research and innovation in CC(U)S, facilitate research networks, explore the conversion of captured CO_2 into chemicals, as well as developing CO_2 capture, transport, and compression techniques.**India – Indian Oil Corporation Ltd. (IOCL):** India's state-owned IOCL commissioned a small-scale CO_2 capture plant at its R&D centre in Faridabad recently, which aims to demonstrate the conversion of captured CO_2 into ethanol and omega-3 fatty acids. The plant will capture up to 3.5 tonnes of CO_2 per year.

Abbreviations

CCS	carbon capture & storage
CCUS	carbon capture use & storage
CO_2	carbon dioxide
DAC	direct air capture
EOR	enhanced oil recovery
EU	European Union
ETH Zurich	Federal Institute of Technology Zurich, Switzerland
GHG	greenhouse gas emissions
H_2	hydrogen
LCA	life cycle assessment(s)
MoU	Memorandum of Understanding
R&D	research and development
US-DOE	United States Department of Energy