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~~L~~ve CO_2 is in the Air

It is no secret that human activity is warming up the planet through the previously unchecked release of greenhouse gases, of which man-made CO_2 is the biggest contributor. Humanity has already started its journey towards **# net-zero by 2050** – but – if we are to achieve the goal of limiting future temperature increases to "only" 1.5 degrees Celsius, we must do more than just reduce emissions: **we need to actively remove carbon from the atmosphere.**

What options do we have?

Given the current energy crisis, is now a good time for CO_2 capture?

Yes, we would argue. In addition to the Paris Aligned 2050 goals, the current global energy crisis is actually accelerating the transition from fossil fuels to green energy, with government support playing an important role. The US, EU, Japan, and Korea already implemented governmental policies aimed at reducing emissions and achieving energy sovereignty, while China and India also announced ambitious climate targets. All in all, global clean energy investments are expected to reach USD 2 trillion per year by 2030 – an increase of over 50% from today's level [1]. Policies concerning carbon capture are next on the list. As a matter of fact, the US already implemented tax breaks specifically for the development and usage of CO_2 capture technology.

Carbon Capture – Technology

Carbon Capture and Storage (CCS); Carbon Capture, Utilization, and Storage (CCUS); and Direct Air Capture (DAC) – all refer to technological approaches of capturing and/or storing carbon.

In a nutshell, CCS refers to capturing carbon directly at the source of emission (e.g., a power plant or a steel producer) as an integrated part of the emitter's industrial process. CC**U**S additionally implies utilizing said carbon for various purposes that range from producing fizzy drinks to assisting in the extraction of oil and gas. DAC refers to dedicated plants that capture carbon directly from the atmosphere.

300
facilities
to go online
by 2030 [2]

Currently, there are more than 30 commercial facilities applying CCUS to power generation, industrial processes, and fuel transformation – with a total capture amount of 45 million tons of CO_2 per year [2], which is not enough to keep us aligned with the 2050 goals given our current annual emissions of over 36 billion tons [3].

389%
increase
in **capacity**
by 2030 [2]

Whereas CCUS implementation has fallen short of rather hopeful expectations in the past few years, it has recently found momentum in the form of 300 new projects that are currently in various stages of development, 200 of which are expected to go online and start capturing a total of 220 Mt of CO_2 by the year 2030 [2].

AKER CARBON CAPTURE

Delta CLEANTECH
CAPTURING SUSTAINABILITY

The technology is already up and running. For example, Aker Carbon Capture ASA is a pure play carbon capture company operating in Norway, Denmark, and the UK. It captures CO_2 in sectors such as waste incineration, bio-energy, cement, gas, as well as other industries. Delta Cleantech is yet another example of a pure-play carbon capture company that is operating globally.

Carbon Capture – Nature's Way

As a side note, carbon capture technology only makes sense if powered by carbon-free energy. Speaking of solar powered carbon capture and storage, there already are well-established mechanisms in place. Better yet, they are rather straight-forward and cheap to 'install' and do not require highly qualified engineers. We are talking about mother nature: trees, bamboo, hemp, or algae – referred to as carbon sinks in this context.

Companies dealing in afforestation and reforestation may immediately spring to mind – but did you know that there are companies out there manufacturing **carbon negative materials?** Bio-plastics, bio-resins, microalgae products, or mycelium (mushroom) materials, just to name a few – all are examples of materials (with various real-world uses ranging from packaging to home-insulation) that "consume" carbon in order to be manufactured. All of these niche industries are expected to grow significantly by the end of the decade. For instance, a market research report by Future Market Insights expects the microalgae market to grow by 59% in the next six years (USD 11.4 billion currently to USD 18.1 billion by 2028) [4].

For instance, **Pond Technologies** grows genetically engineered algae that is not only very good at capturing carbon, but also useful in various other applications such as diagnostics, therapeutics, medicine, and nutrition. **Origin Materials** is one of the global leaders in producing various carbon negative materials out of biomass.

59%
growth of **microalgae** market by 2028 [4]

39.5 kg
CO_2 absorbed per m^3 of **mycelium insulation** [5]

1.5 tons
CO_2 absorbed per 100 m^2 of **wooden shiplap** [6]

217%
increase in **bioplastic production** by 2026 [7]

Pardon this Particular Carbon!

Similarly, there are **carbon neutral products** that release the carbon they captured when they were produced. BECCS stands for Bio Energy with Carbon Capture and Storage. We are talking about bio-diesel, bio-jet fuel, cellulosic fuel, or coal pellets made from bamboo.

In addition to **bio-fuels**, there are also **synthetic fuels** (or e-fuels), which are produced by combining captured carbon with hydrogen obtained through electrolysis. If the carbon capture and electrolysis processes are powered by clean energy, these fuels are carbon neutral (burning them would only release the captured carbon).

Together with carbon-negative materials, bio-fuels and e-fuels provide a direct way of continuing to use our established infrastructure while having no negative impact on the environment. Building a new house? Use mycelium insulation. Insufficient global supply of rare-earth metals for battery and EV production? Use bio-fuels or e-fuels in your internal combustion car. Do you like your supermarket veggies wrapped up in packaging? Use bioplastics. **Saving the environment may require less compromise than you thought.**

e-fuels are produced by **combining** captured **carbon** with **hydrogen**

PORSCHE invested USD **75 million** in **e-fuels** in 2022 [8]

Mazda [9] race car now **powered** exclusively by **biodiesel**

Japanese **CO_2-neutral fuel alliance**: Toyota, Mazda, Subaru, Yamaha, and Kawasaki [9]

Is Carbon Capture Investible?

Absolutely! Courtesy of our in-house natural language processing algorithm, **ARTIS**, we can construct an index that combines all the concepts discussed above. Namely, we can identify companies that fall into one (or more) of the following buckets: pure-play carbon capture technology, carbon negative products, and carbon-neutral products. Here are some of the most prominent listed companies in each sub-theme:

Pure Play Carbon Capture Tech	Carbon Negative Products	Carbon Neutral Products
AKER CARBON CAPTURE Delta CLEANTECH CAPTURING SUSTAINABILITY	ORIGIN pondtech Weyerhaeuser	AEMETIS gevo TIDEWATER RENEWABLES bbgi MONTAUK RENEWABLES Verbio Biofuel and Technology Renewable Energy Group Blue biofuels

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[7] I. Riseo, "Bioplastics Global Production Capacity by Type (2020-2026)," Statista, 2022.

[8] T. Harloff, "Porsche-E-Fuels künftig auch aus Tasmanien," Auto Motor und Sport, 2022. [Online]. Available: https://www.auto-motor-und-sport.de/tech-zukunft/alternative-antriebe/synthetische-kraftstoffe-porsche-intensiviert-e-fuel-forschung/.

[9] T. Harloff, "Nach Wasserstoff kommen E-Fuels," Auto Motor und Sport, 2021. [Online]. Available: https://www.auto-motor-und-sport.de/tech-zukunft/alternative-antriebe/toyota-konzern-allianz-mazda-subaru-kawasaki-yamaha-forschung-e-fuels-synthetische-kraftstoffe/.

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