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The Climate Tech Startup Corner...

WHY CARBON-REMOVAL SOLUTIONS ARE KEY TO FIGHTING CLIMATE CHANGE

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CARBON REMOVAL – THE KEY TO FIGHTING CLIMATE CHANGE

climeworks

Zurich-based start-up Climeworks was founded in 2009 to help address the massive challenge of climate. The company uses direct air capture (DAC) technology to capture CO_2 directly from the air, reducing the atmospheric concentration of CO_2 by only using renewable energy, energy-from-waste, or other waste heat as energy sources. In addition to getting corporate clients to pay for future removals, Climeworks has raised more than $810 million from a wide variety of investors to scale up.

Dr Nathalie Casas heads R&D at Climeworks. She is also a member of the innovation council of Innosuisse – the public Swiss innovation agency. The Capgemini Research Institute spoke to Dr. Casas to understand why carbon removal is key in our fight against climate change.

The Climate Tech Startup Corner

The enormity of the challenge posed by global warming can be daunting. What can any individual, organization, or even country do to fight climate change? We can and must make changes to our current lifestyles, but this alone won't be enough to stop temperatures from rising. The science is clear: to have a chance of keeping the global rise in temperature below 1.5°C, we need to get the world to net zero, as quickly as humanly possible.

This means doing everything we can to reduce our carbon footprint and actively removing the CO_2 we have already emitted into the atmosphere. We need to extract billions of tons of CO_2 between now and 2050, a task so gargantuan that we will need all known carbon-removal solutions to work together, uniting nature and technology in urgent symbiosis.

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Why is carbon removal so important?

Let's talk about unavoidable and historical emissions.

The most important thing any of us, individuals or companies, can do to stop global warming is to shrink our carbon footprints. According to the Intergovernmental Panel on Climate Change (IPCC) and the Science Based Targets initiative (SBTi), companies must reduce their CO_2 emissions by at least 90% before 2050. However, that will still leave around 10% of current levels of unavoidable emissions. Carbon removal is crucial to neutralizing these emissions and keeping global warming at around the 1.5°C target.

Then, there's the matter of "historical" CO_2 emissions already released into the atmosphere. There are billions of tons of historical CO_2 emissions in our atmosphere, which must be removed if we are to go beyond carbon neutrality and achieve net negative emissions (i.e., removing more CO_2 from the atmosphere than we pump into it). Carbon removal is the only way to achieve this and, in doing so, take the first steps in restoring balance to our climate.

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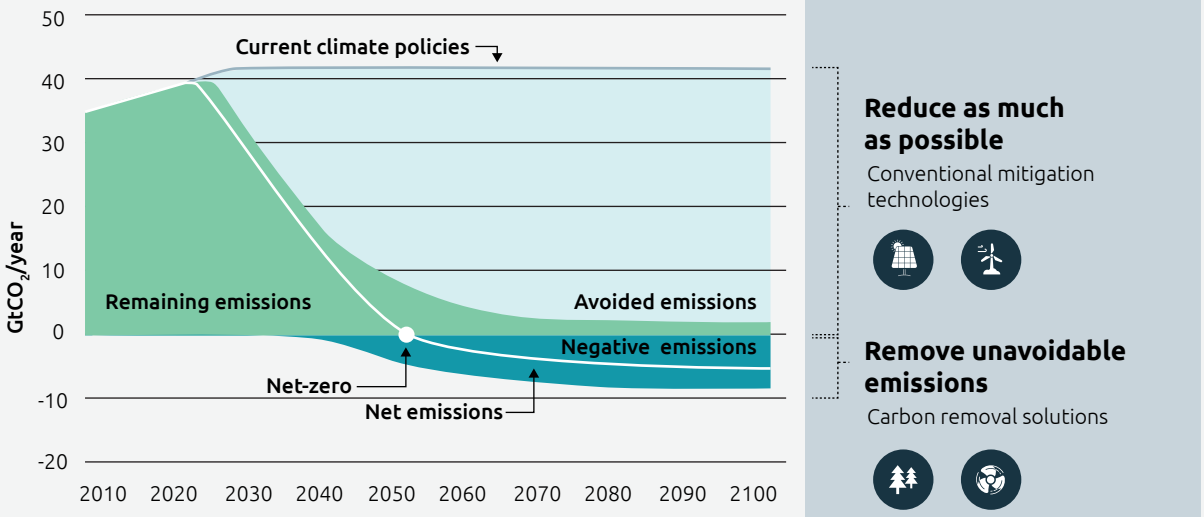
Beyond unavoidable and historical emissions, carbon removal is also an important safeguard in the fight against climate change. If, despite drastic efforts to reduce emissions, a temperature overshoot takes us above 1.5°C, additional carbon removal could help us bring the temperature down again.

THERE ARE BILLIONS OF TONS OF HISTORICAL CO_2 EMISSIONS IN OUR ATMOSPHERE, WHICH MUST BE REMOVED IF WE ARE TO GO BEYOND CARBON NEUTRALITY.

Figure 1: Why carbon removal matters



Source: Climeworks.

Some effective carbon-removal solutions:

There are a variety of carbon-removal solutions available. Let's look at some of the more viable options.

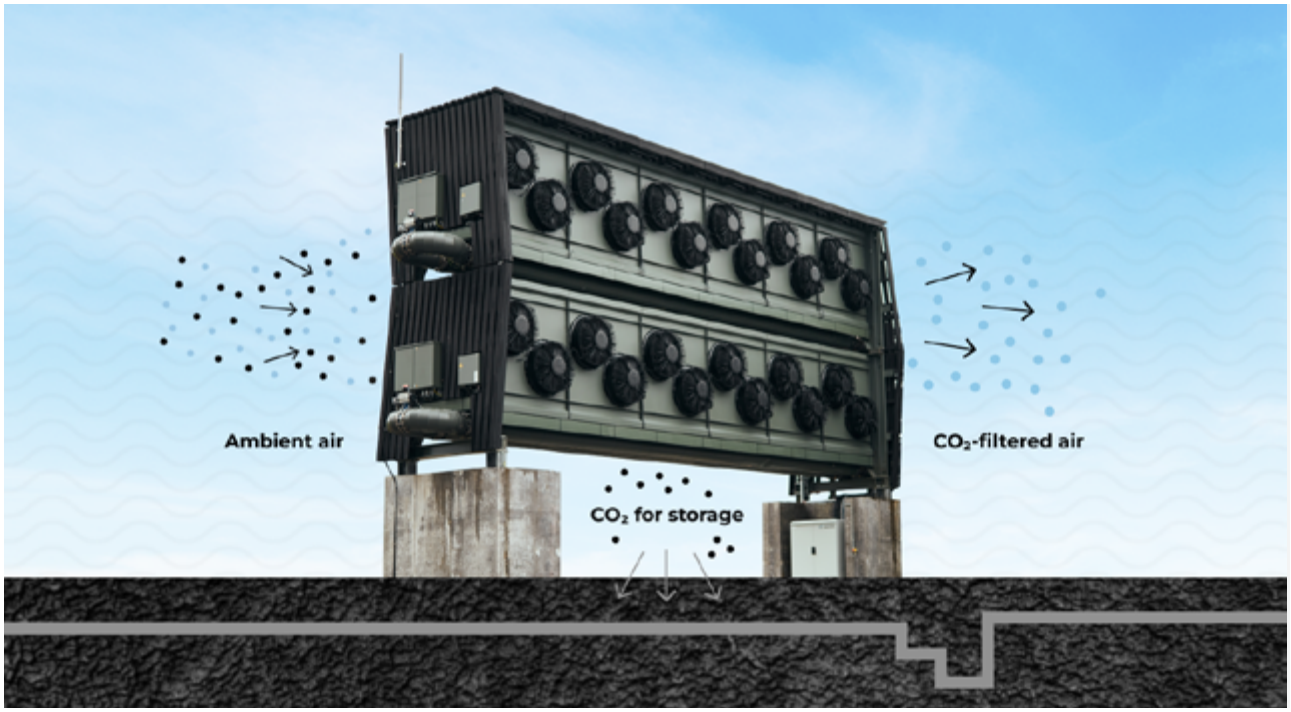
Direct air capture:

Direct air capture (DAC) is a technology that captures CO_2 directly from the air and, when combined with storage technology (DAC+S), locks the captured CO_2 permanently deep underground. Our storage partner – in Iceland, this is Carbfix – transports the CO_2 deep underground, where, through a natural reaction with basalt rock, it transforms into stone, theoretically remaining in this state for over 10,000 years. This allows us to offer companies and individuals a high-quality, effective, and permanent removal of unavoidable and historical emissions.

In practice, DAC is a three-step process:

1. Air is drawn in using fan-generated suction. Once inside, it passes through a filter that traps the CO_2 particles.
2. When the filter is completely full of CO_2, the collector closes, and the temperature rises to about 100°C – the same temperature it takes to boil water for a cup of tea.
3. This causes the filter to release the CO_2 so we can finally collect it.

Figure 2: Climeworks' DAC plant in Iceland: Orca



Source: Climeworks.

> **Direct air capture (DAC) is a technology that captures CO_2 directly from the air and, when combined with storage technology (DAC+S), locks the captured CO_2 permanently deep underground."**

There's global potential for DAC+S, from the Middle East to North America. We're currently investigating new opportunities in the US, Norway, and Oman.

Climeworks' DAC system is one of the key technological weapons in the battle against climate change. It captures CO_2 directly from the air, reducing the atmospheric concentration of CO_2 by only using renewable energy, energy from waste, or other waste heat as energy sources.

Each solution, whether natural or technology-based, has its benefits and drawbacks, making it essential that all approaches work in synergy if climate targets are to be achieved. Below are the **benefits of DAC:**

- **Location-independent:** CO_2 concentration is the same everywhere in the world. As there is no specific emissions source, this means that DAC plants can, in theory, be located anywhere there is a renewable-energy source and a suitable site for CO_2 storage.
- **Highly scalable and measurable:** Climeworks' plants are based on a modular-technology design, making them highly scalable. We can also measure exactly how much CO_2 our machines capture.
- **Efficient land usage:** Climeworks' plants require less land than other techniques. For example, on a land area of 0.42 acres, our Orca plant can remove 4,000 tons of CO_2 from the air every year – this is almost 1,000 times more efficient than trees (the same land area would host around 220 trees with an estimated capacity of 22 kg each, giving an annual carbon-removal capacity of only 4.62 tons of CO_2).

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Afforestation: Planting more trees

Trees are an excellent natural solution because they reduce the amount of CO_2 in the atmosphere by absorbing it and storing it for long periods of time – centuries, in some cases.

Naturally, however, there are downsides:

- Trees are vulnerable to fire and disease; once cut down or rotting, they release all the carbon dioxide they've captured up to that point.
- A tree can only store CO_2 over its lifetime (average ~100 years).
- Afforestation requires a great deal of water, and, most importantly, time; young trees absorb far less CO_2 than do mature ones, meaning that a newly planted forest could take decades to absorb the levels of CO_2 we need to lock away.
- Trees need a lot of space: to generate sufficient CO_2 storage capacity we would need to afforest an area the size of Europe.
- Protecting and strengthening our forests to ensure that they continue to serve as natural carbon sinks is of the utmost importance, but pinning our hopes on tree planting is not credible.

A NEWLY PLANTED FOREST COULD TAKE DECADES TO ABSORB THE LEVELS OF CO_2 WE NEED TO LOCK AWAY.

Bioenergy with carbon capture and storage (BECCS)

To prevent CO_2 emitted from biomass, such as trees, from ending up in the atmosphere, the biomass can be burned in a power plant, following which the CO_2 released is captured and then buried. BECCS allows for the creation of energy as a secondary activity.

Why has it not yet been implemented at scale?

- To achieve the required level of CO_2 removal, this process would require access to an area of arable land equivalent to more than twice the size of India (i.e., half the current global arable land area).
- The required levels of water and fertilizer are very high and could impact food production if redirected to BECCS.
- It is imperative that CO_2 emissions from the growing, harvesting, and processing of biomass don't outweigh total carbon captured.

Enhanced weathering

Enhanced weathering is a technology that mimics and accelerates the natural climatic weathering process of rocks. Rocks exposed on the Earth's surface absorb CO_2 from the atmosphere and, in the presence of water, transform it into other compounds, retaining CO_2 for a long time.
This solution accelerates this process by spreading finely ground rock over the land surface (farmland, beaches, forests, etc.); this results in a greater area of rock surface being exposed to the atmosphere, and therefore available to absorb carbon.

Benefits include improving degraded soils and plant growth and helping to reverse ocean acidification. However, there are a few uncertainties:

- Scientists suggest that rapid, uncontrolled changes in pH value, carbonate-saturation state, and dissolved aqueous CO_2 could affect ocean ecosystems.
- Although this technology mimics a natural process, it's not itself natural per se; the substance used is released into ecosystems at much higher rates than normal and could create "dead zones" in which oxygen levels are too low to support life.
- These are only some of the available solutions; all must be evaluated carefully and as a matter of urgency, including in terms of scaling potential and applicability to the central struggle against climate change.

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