Direct Air Capture (DAC) The World's Largest Air Purifier

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Climate change is a worldwide problem, how and what can we do about it? What is being done already?

The Paris Agreement

The Paris Agreement was created and signed in 2015 and was an important agreement that has affected the world. The agreement was signed by 196 countries at a United Nations Climate Conference in Paris and set up goals and guidelines such as, we all need to work to limit global temperatures below 2 degrees Celsius and then further limit it to 1.5 degrees, which means getting the levels of greenhouse gasses down. Two other rules were created. First, the UN must review all the countries' commitments to the goals every five years to make sure that the countries are on track. Second was that all countries had

to give funding to developing countries to mitigate climate change. This is a big help for those countries because many can't afford to use clean energy and end up creating a lot of excess waste and emissions.

What are greenhouse gases?

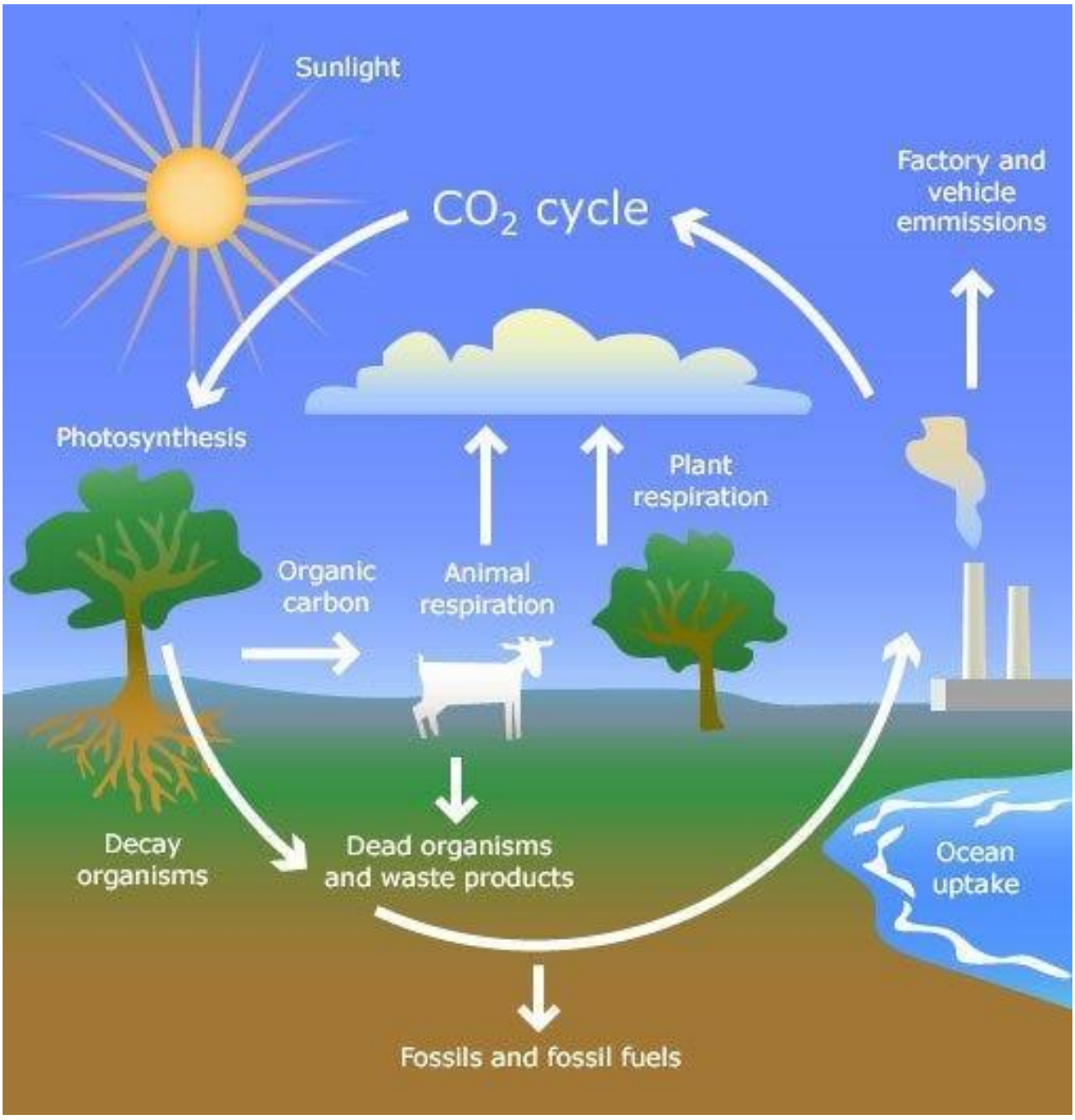
There are many different types of greenhouse gases, which are meant to be positive as they keep the earth at a habitable temperature. Before the Industrial Revolution and the use of coal and fossil fuels as a main power source. Some of the radiation from the sun was absorbed into the earth's surface which helped keep our earth warm, while the rest was bounced off the earth's surface. Most of these reflected rays escape our atmosphere and some are captured by naturally occurring greenhouse gasses. But an excess amount of anything is harmful and, in this case, that observation still goes for the purposeful little amounts of naturally occurring greenhouse gasses in our atmosphere to the 2,400 gigaton's of Carbon Dioxide alone released by industrial processes. These greenhouse gasses make it even harder for the light and heat in our atmosphere to get out. When light rays come from the sun into our earth's atmosphere, they are reflected off the earth's surface. Greenhouse gases work when the reflected rays absorb the rays or heat and then re-emit the heat. With more and more CO_2 alone coming into the atmosphere, climate change will be and most certainly has been affected. This will be extremely noticeable in weather patterns, temperature, storm sizes, droughts, loss of animal species, rising ocean levels and lack of food.

Why is carbon dioxide such a big focus?

1. Carbon Dioxide accounts for around 76% of greenhouse gasses in the atmosphere, while it is not the most abundant next to water vapor which varies in concentrations, it is the most prominent of the gasses and the most dangerous.

2. CO_2 remains in our atmosphere much longer than the other gasses. While methane takes a decade to leave the atmosphere and a century for nitrous oxide, 40% of the CO_2 will stay in the atmosphere for 100 years, 20% for 1000 years and 10% for the next 10,000 years. Meaning that in the long term, CO_2 will have a bigger effect than other gasses.

3. The ocean absorbs the CO_2 due to a balance that has been going on for hundreds of years, when the ocean absorbs too much CO_2 its basic properties become acidic, and it is harmful to the marine ecosystems.



What are the carbon capture and carbon capture and storage technologies?

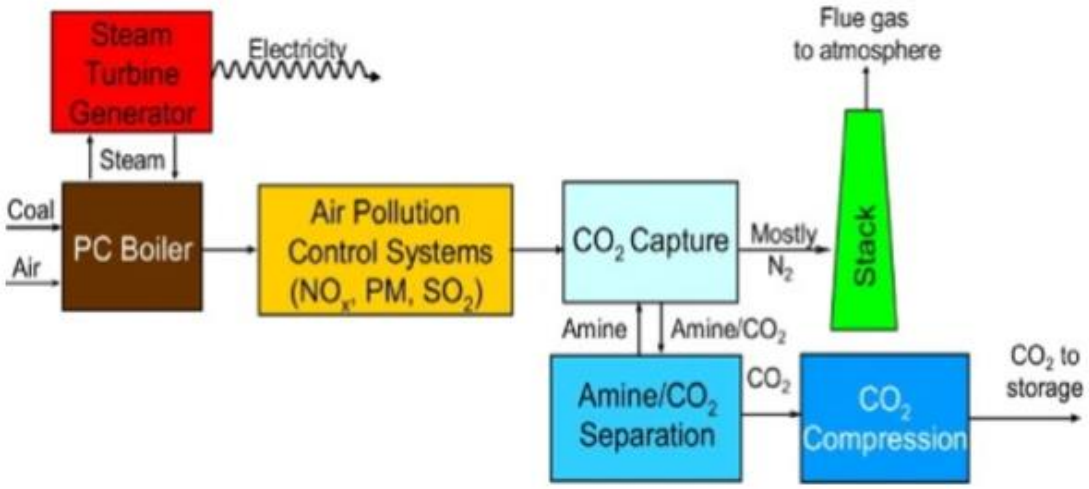
Carbon capture and storage (CCS) is a term for technologies that capture CO2, these methods capture the CO2 from the atmosphere, right from the source or sometimes from

the ocean. After the capture process occurs the CO2 is then stored in either rock formations, under the ocean, in the ground or temporarily stored to then be utilized for consumer products.

Capturing the CO2

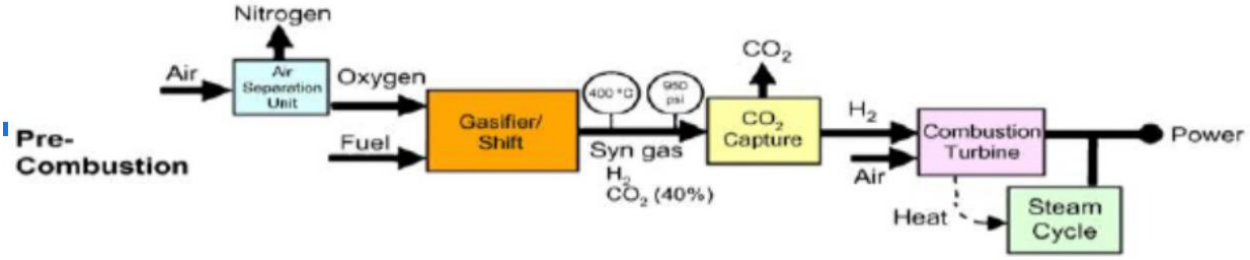
Carbon capture is done in a few different ways.

- Post-combustion capture: This method captures carbon dioxide by separating the CO2 from the flue gas (gas exiting the atmosphere via the flu or a pipe) using a liquid amine scrubber to absorb the CO2. It can then be stripped of CO2 to be used once again. This process essentially treats the flue gas before it is released into the atmosphere. And is commonly used in power stations.

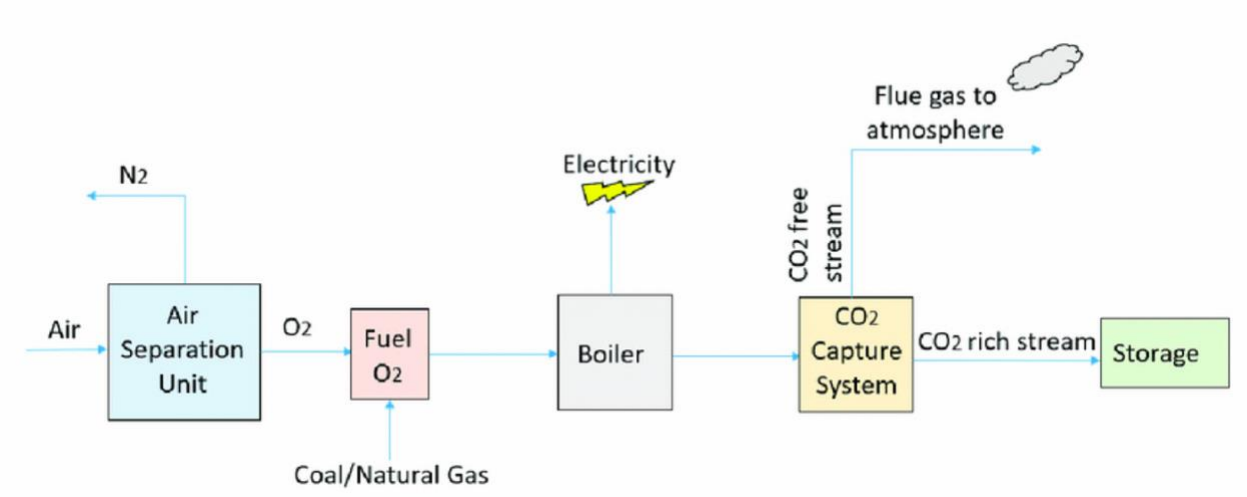


- Pre-combustion capture: In this method of carbon capture, carbon dioxide is removed from fossil fuels before they are used. This is done by oxidizing coal

in air and oxygen under high temperatures. This process is commonly used in integrated gasification combined cycles (power plants).



- Oxyfuel combustion: This method is done by eliminating nitrogen from the combustion medium, once nitrogen is eliminated you only have CO2 and H2O left. To remove the H2O a condensation process occurs to then have the CO2 be captured with just itself. This is used in fossil fuel power plants and the iron and steel industry.



- Bioenergy with CCS: In this method, electricity is produced by burning biomass like roots, leaves and wood and capturing the stored CO2; from the photosynthesis process of plants.

- Photosynthesis is another way that carbon capture is used, planting trees though it is not technically a technology produced by humans. It is a way of

capturing CO_2, this happens when organisms like trees and some crops absorb water and CO_2 from the soil and air. The water is then oxidized (loses electrons) and the CO_2 is reduced (gains electrons), this process transforms water into oxygen and the CO_2 into glucose. The CO_2 is then "captured" and stored inside the plants until they die, which is then released.

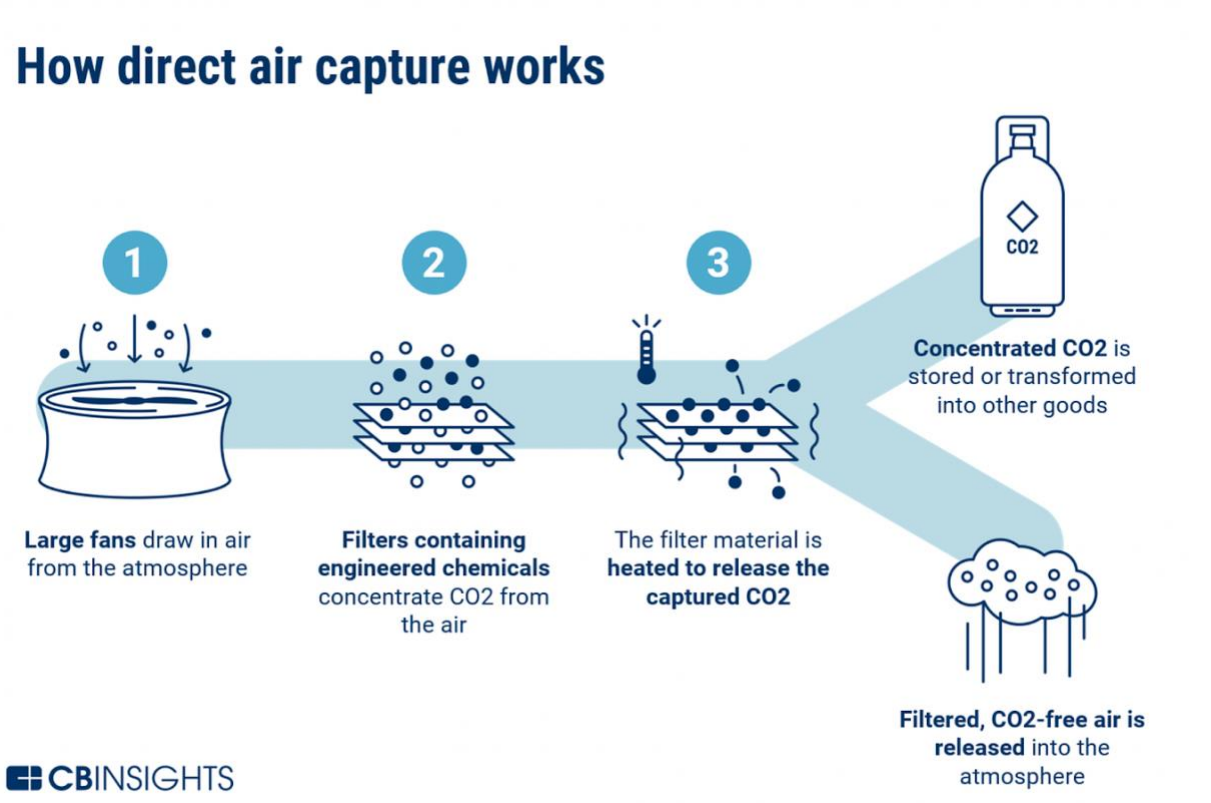
Lastly is Direct Air Capture, direct air capture is often referred to as a large air purifier. Instead of capturing dust, it captures CO_2 from our atmosphere.

Climeworks

Climeworks is a Swiss company that has been making large strides in the carbon capture realm. Their direct air capture technology differentiates itself from other companies for many reasons, their capture process, energy efficiency, efficiency in capture process and its partnership with storage companies.

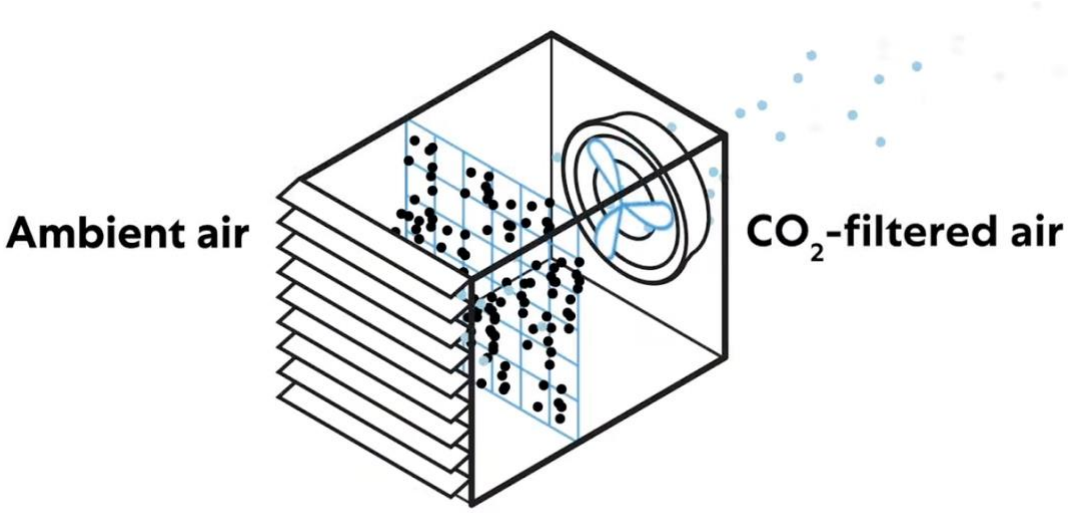
The process of Climeworks

Climeworks direct air capture technology works in three sections drawing in the CO_2, filters catch the CO_2 then the filter is heated to release the CO_2, after the capture process the captured CO_2 is either stored or utilized by companies.



Collecting air

The first stage of all direct air capture technologies is the collection of air, in this stage, large fans draw the air inside the collectors.

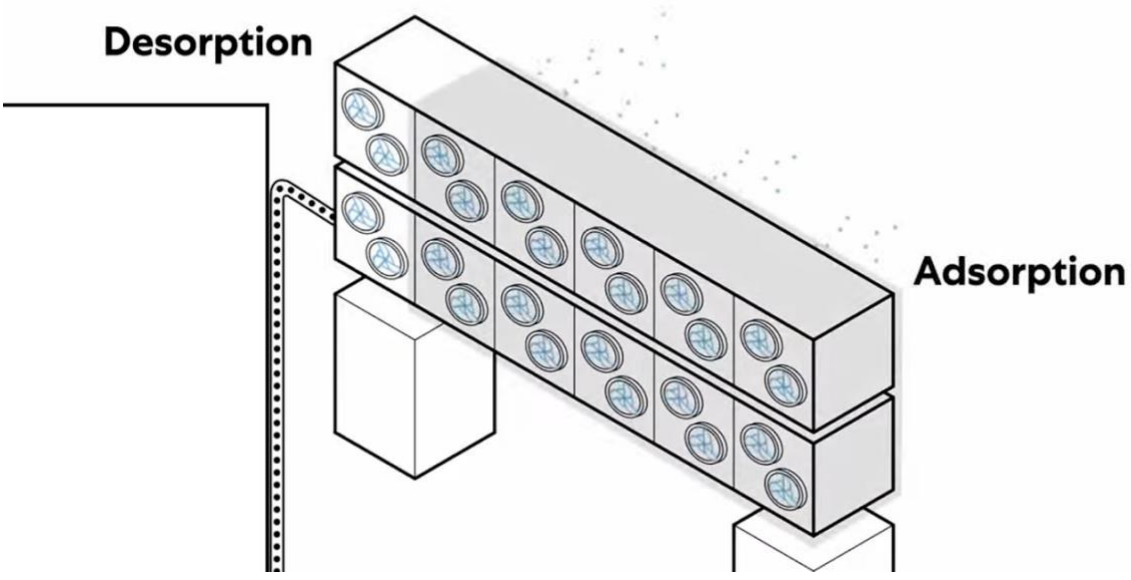


Fans

The Climeworks fans are made from robust axial fans from a well-known fan company, they are designed to withstand the harsh elements found in Iceland. There are 12 fans in each collector that pull air through the collectors, they are located at the back of the containers. The Climeworks fans draw in around 500 tons of CO_2 annually, with all 8 drawing in around 4,000 tons annually. Due to the high-quality fans, their efficiency is at around 90% with a goal of 96% with further innovation.

Collectors

The Climeworks collectors are one of their biggest differentiators to other companies, there are 8 collectors in the Climeworks unit, with 2 of them working in the desorption stage while the other 6 are in the absorption stage. Each collector is about the size of a shipping container.



Energy and money

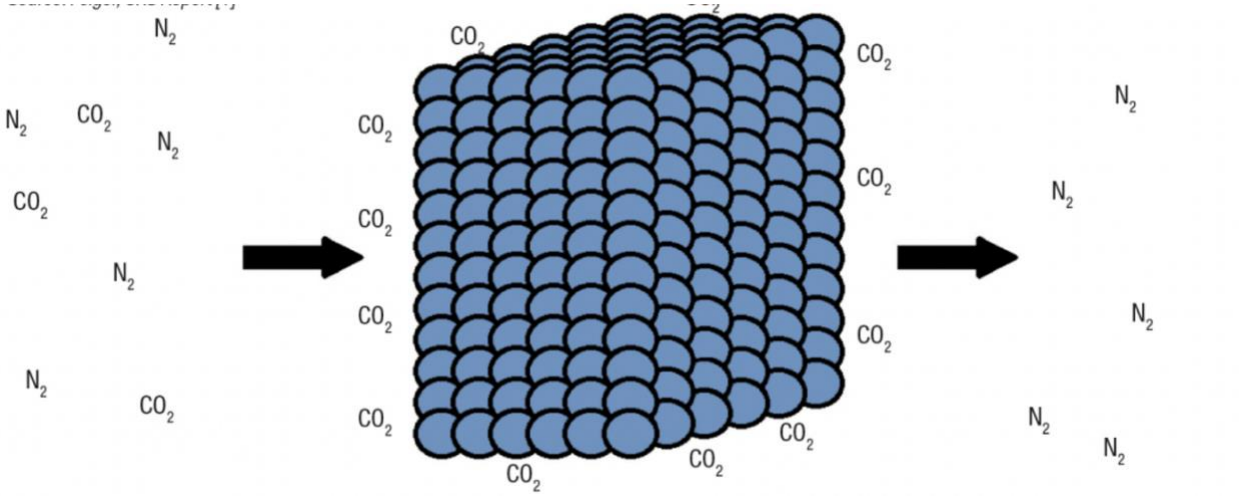
There is a lot of money and energy required for the collection of CO2, it takes around 12 gigajoules of energy per tonne of CO2. That is the equivalent of the energy consumed by one household during 4–5 months. In terms of expences, it takes around $600 to $800 to remove one ton of CO2, Climeworks aims to get the cost down between $100 and $200.

The filters

The second stage of direct air capture is the filtration of CO2.

Climeworks filter

The Climeworks filtration system utilizes a filtration material that consists of a highly porous material made from chemical compounds called amines along with special cellulose fibre. Amines are a highly selective chemical that is extremely efficient at capturing CO2 from the air. The cellulose fibre provides structure and support for the amines. The air passes into the collectors through to the filters then the highly selective filter material captures the CO2, and the rest of the air can pass through to the front of the collector.

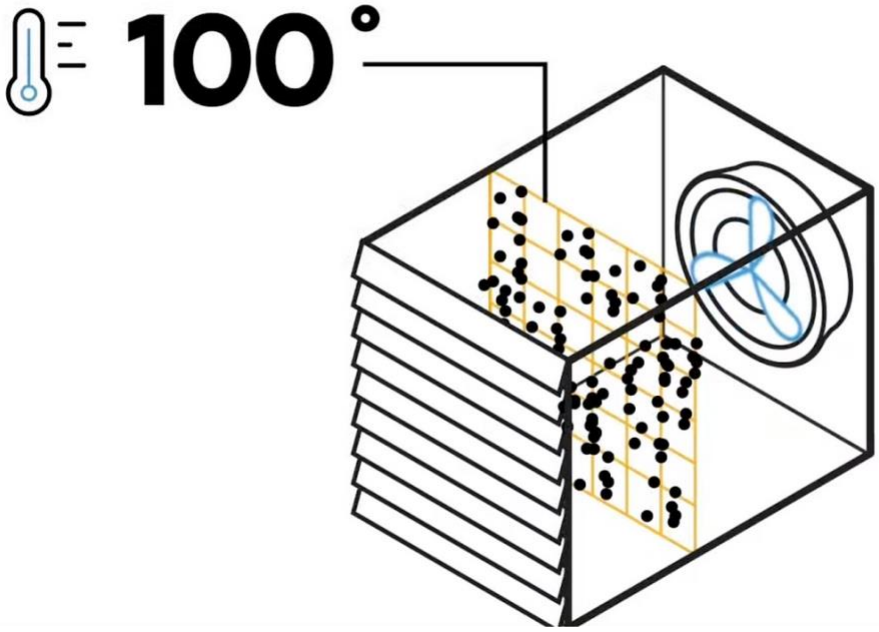


How do the amines capture the CO2

The process of capturing CO2 is called absorption. As the air is pulled into the collector the amine-based filter on the cellulose filter reacts with the CO2 in the air and binds it to the surface of the filter. Due to the reversible nature of the amines, they can be reused for several thousand cycles making them sustainable.

The releasing mechanism

The reversible mechanism of the amines comes from this next stage. After the bond is created between the CO2 and the amines, it needs to be broken to let the CO2 be captured. Once the amines are saturated with CO2, the collector closes, and a process referred to as desorption begins. As the collector is closed the filter material is heated to around 100 degrees Celsius, this breaks the somewhat weak chemical bonds that were created in the absorption process.



Storage and utilization

After the carbon is fully captured and in its highly concentrated gas form, the carbon must go somewhere.

Where is most of the CO2 stored?

Geological storage

The majority of CO2 is stored underground in naturally occurring porous rock formations, such as former oil or natural gas reservoirs, old coal beds that are unable to be mined, or saline aquifers. These are very deep geological formations with deposits of very salty water within the pores of the rock. CO2 is injected into these formations and after some time it reacts with the minerals in the formations to form carbonates. This is a

process known as geological sequestration, Climeworks in partnership with Carbfix, deposits captured CO_2 deep into geological formations in Iceland.

Mineral storage

Mineral storage of captured carbon is known as mineral carbonation. In this process, a chemical reaction occurs which allows CO_2 to form stable carbonates with rocks.

Ocean storage

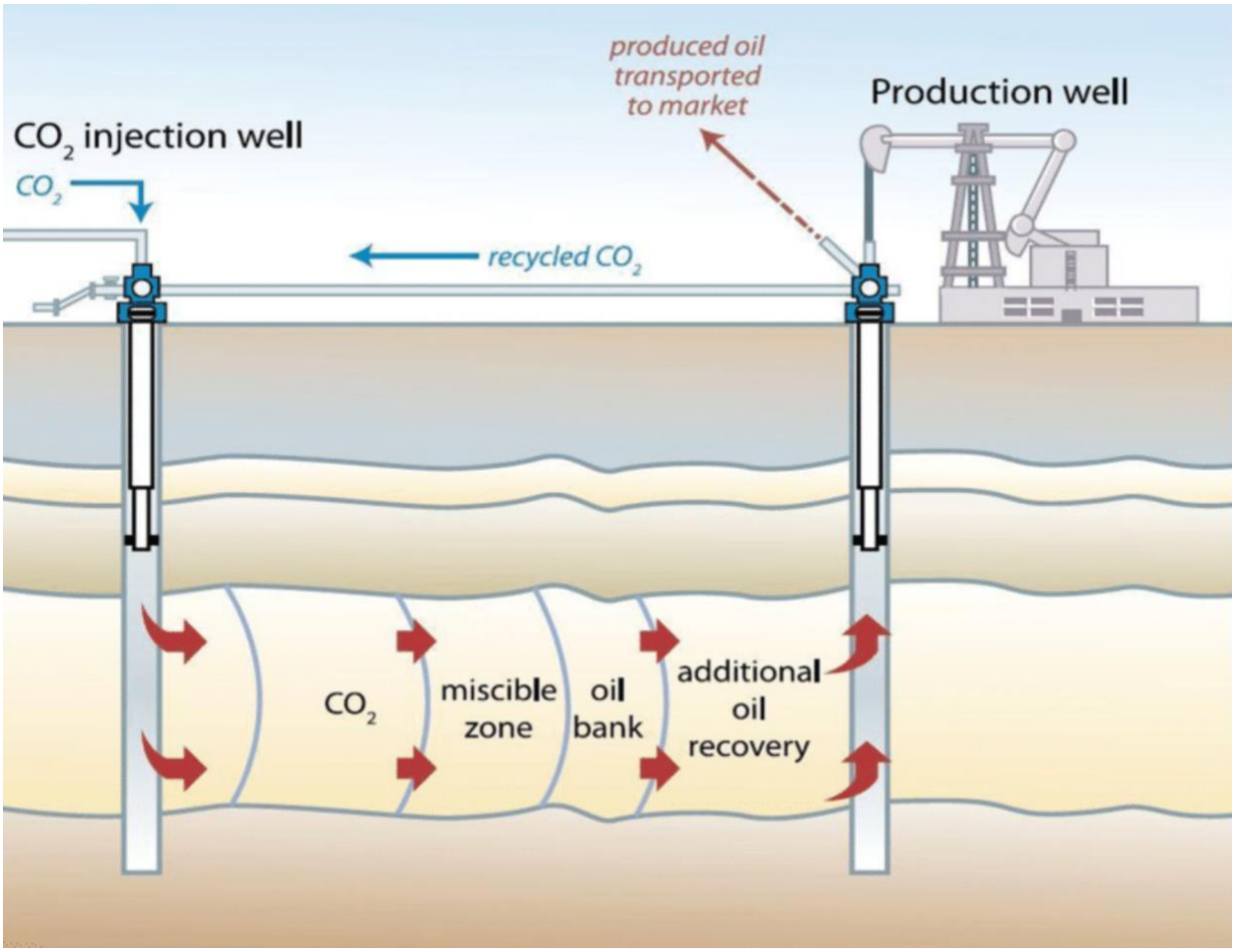
Another name for ocean storage is direct deep-sea carbon dioxide injection, this was once considered to be a potential storage option. Now it is not seen as a possibility due to the high costs, and lack of permanence as the damage that carbonates would form would do to the marine ecosystems would cause ocean acidification.

Utilization

- Aviation is one sector that is exploring the uses of captured carbon. CO_2 has the potential to create a synthetic low-carbon fuel. The process involves using electrolysis, which separates CO_2 and oxygen and then recombines the CO_2 with hydrogen to create fuel.
- Carbonated drinks are a sector that is already utilizing the CO_2, in this process, CO_2 is injected into the drinks to make them fizzy. This process is not permanent, as the CO_2 continues to be released until it becomes flat.

- Carbonated drinks are not the only drink sector that has a use for CO_2, Carbon Dioxide is also used to decaffeinate drinks. In this process, CO_2 is used as a solvent and does not get released after use, so it's almost like a permanent solution.

- Enhanced oil recovery (EOR) is a process where CO_2 is injected into oil reservoirs to enhance oil recovery, this process allows captured carbon to be stored whilst also pushing out the excess oil that would not be accessed otherwise, making it very profitable for the oil companies. This process also allows for the oil companies to burn the oil which in turn releases more carbon dioxide into the atmosphere. This means that the enhanced oil recovery process is just a cash grab for oil companies to push the idea that they have become carbon neutral. Chevron is a company that uses captured carbon for enhanced oil recovery. The company announced its first large-scale usage of EOR in 1972 and now EOR has contributed significantly to their oil production.



- Cement and concrete are an up-and-coming industry that is using captured CO2. Captured carbon can be utilized to create carbon-negative green cement, transforming carbon into raw materials for production. In concrete production, the use of CO2 can cure regular cement which can cut down on the cement needed and reduce cement emission. There is also another way of utilizing CO2 in concrete production, by mixing/sequestering it with the cement, which makes it stronger and provides permanent storage.

Innovative companies utilizing and storing CO2

- Blue Planet is a company that rather than using CO_2 to treat other materials is using it to make a material of itself. This method involves turning CO_2 into carbonated rocks which can be used as a substitute for limestone. This is really an amazing company because carbonated rock is a permanent storage solution that can last for years, and the end product can be used in concrete production.

- CCM Technologies is a company that is making strides in the fertilization industry. The company is focused on resource optimization, which includes the conversion of carbon dioxide into valuable products such as low-emissions fertilizers. The company is known for its potential to accelerate decarbonization and improve the sustainability of agricultural processes.

- Dyecoo is a company based out of the Netherlands, they work to take down the emissions in the textile industry. 1.2 billion metric tons of CO_2 are emitted per year, which is coming close to the emission level of the automobile industry. The company has developed a way of utilizing CO_2 to create new dye for textiles. This is done by pressurizing the CO_2 until it reaches a point of high solvency.

- Arbon Earth is a company that uses algae to sequester, and store captured carbon. Using fast-growing algae, the company can sequester it in the seabed. The algae are grown on ropes offshore and it eventually sinks below the surface to become fully grown, which binds the CO_2 in the seabed for long periods of time. In addition to becoming a storage way for CO_2, the algae are also used in fish nurseries as it provides a habitat.

- RedoxNGR is a company that captures carbon using renewable energy to electrochemically capture CO_2 from the atmosphere. Their device later converts CO_2 into formic acid through electrolysis. Formic acid can then be utilized for other industries.

- Air Company is a New York-based Startup that is creating impurity-free alcohol. Their alcohol is used in perfume-making, vodka, and cleaning agents.

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