Carbon Capture: Will it save us or end us?

Global warming is one of the major problem and the cause for that is the increasing amount of Global warming is one of the major problems we must contend with. The primary cause for that is the increasing amount of greenhouse gas emissions (GHG). The chart below shows the proportions of global GHG emissions by sector.

Global green house gas emissions by different economic sectors. Source: IPCC 2014

Every day, we release gases such as carbon dioxide, methane, and others into the atmosphere. These gases cause global temperatures to rise, an effect called the greenhouse effect. While we need some greenhouse gases to keep our Earth habitable, we exceed that amount. Too many gases are entering our air. Increased temperatures change our ecosystems, leading to devastation and death. Clearly, we need to find a solution. One proposed solution is carbon capture and storage.

Why capture carbon dioxide?

Burning fossil fuels to produce energy emits carbon dioxide into the atmosphere. Accordingly, emission sources include power generators, automobile engines and furnaces. Carbon dioxide emissions also increase due to industrial extraction processes, and even through the burning of forests during land clearance.

While natural processes such as decomposition release some greenhouse gases, natural carbon sinks such as trees and water bodies tend to absorb this. However, human activities such as industry and fossil fuel burning have tipped the balance, meaning more greenhouse gases and warmer temperatures.

We need a solution to solve this problem. Could technology give us an answer? Carbon Capture and Storage (CCS) is one proposed solution. Even though still in its infancy, if effective, it could ease our impacts on our planet.

How do we capture carbon?

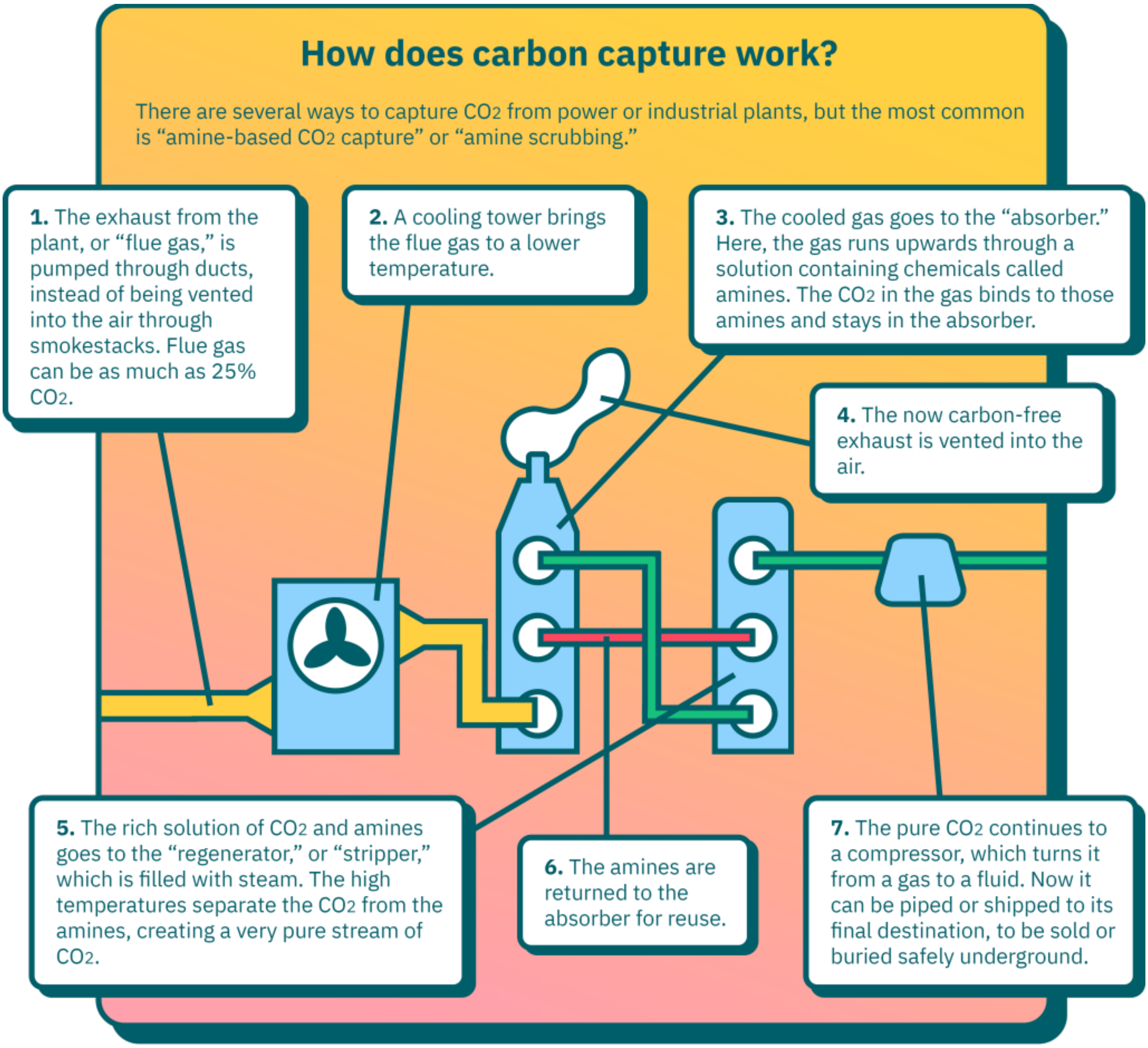
CCS technology aims to capture carbon emissions from burning fossil fuels, to store this deep underground. This involves three major parts: Capture, transport, and storage. It works by diverting polluting gases through a chemical solution. This absorbs the carbon dioxide. This is then compressed to a liquid form and stored deep under the ground. These tend to see use at power plants and manufacturing facilities.

Types of CCS technology

There are 3 main types of CCS technology, including:

Post-combustion

With this technology, exhaust gases flow through absorbent chemicals, such as amines (made from ammonia). These capture the CO_2 inside. Most of these systems release carbon-dioxide by passing superheated steam along through the mixture, so it can be stored.



A typical amine-based carbon capture process. Source: MIT Climate Portal

Pre-Combustion

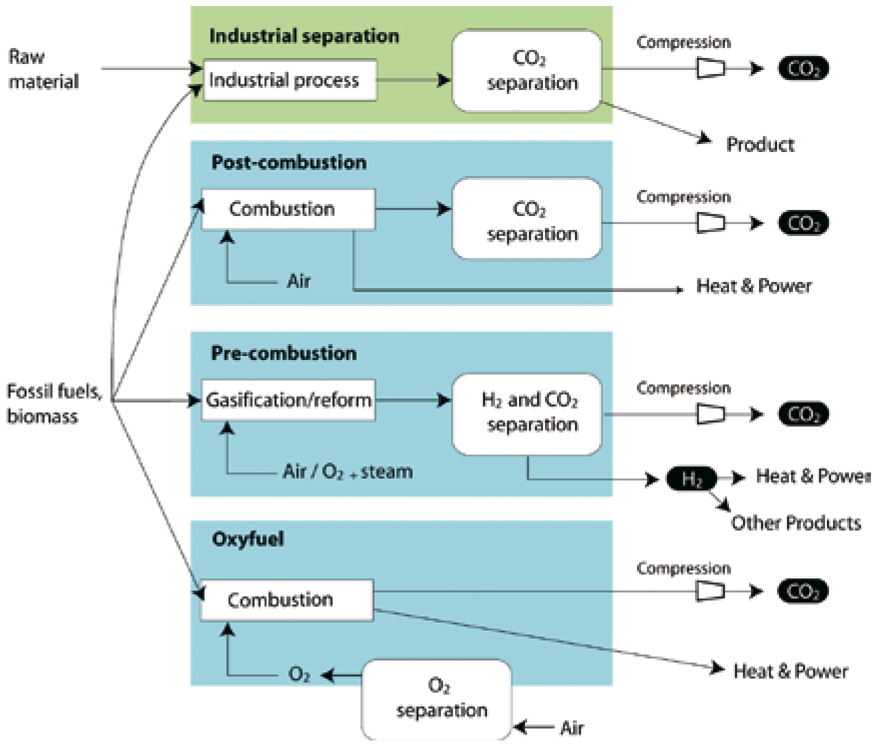
This technology aims to reduce coal power emissions by processing it beforehand. The coal is converted to gas before the energy production process, producing hydrogen and carbon monoxide. The carbon monoxide interacts with water to produce carbon dioxide, which is captured. The resulting hydrogen can then produce electricity.

This, unlike post-combustion technologies, does not work with existing coal plants. In addition, while there is the possibility of applying this to natural gas power stations, there is no proof that this is more effective than post-combustion.

Oxyfuel

Fossil fuels are normally burnt in air, mixing carbon dioxide in exhaust gases. Burning them in pure oxygen means that almost all waste gases are CO_2 and water. Separating the carbon dioxide is as simple as condensing the water away.

However, the main issue is that it's inefficient. To create oxygen for burning, air must be frozen to very low temperatures to release the oxygen. For a typical plant, it can take at least 15% of a plant's annual electricity output, dramatically reducing its ability to create power. However, new technologies may help solve this issue.



Schematic diagram of capture systems. Source: IPCC 2005 report on Carbon dioxide capture and storage.

Is carbon capture effective?

As mentioned above, CCS technology can be expensive to both setup and run. Estimates suggest electricity from carbon capture may be over six times as expensive as renewables. Even compared to typical coal plants, CCS systems are shown to increase electricity costs by an extra two-thirds.

As a result, there are only 51 large-scale CCS projects across the world, many of which are under construction. However, there are plans to build 30 more.

Several issues also exist with carbon capture itself, including high technology costs and the potential for CO2 leaks. These have all but stopped their use in commercial applications.

However, if successful, we may be able to use the captured carbon dioxide to push out oil from wells. Known as Enhanced Oil Recovery (EOR), this can extend the life of oil fields while keeping CO_2 underground. This, however, does not deal with pollution created by oil wells in the first place.

Captured CO_2 could also create products such as plastics, carbon fibres, paints, or even used to grow fertilisers. These, however, are only made in small amounts.

Carbon capture technologies

The effectiveness of CCS depends on advancements in technology. To this end, there has been much research into making surfaces that absorb carbon more effectively. For instance, metal-organic frameworks and other absorbent surfaces with large surface areas could be useful to make more effective carbon capture solutions.

Chemical Looping

Another example is chemical looping. This technology provides pure oxygen by oxidising small slivers of metal and inserting them into power station furnaces. This results in oxygen and carbon mixing to form carbon dioxide. While it uses little energy to remove CO2 compared to other methods, the metal particles can damage plant interiors, meaning greater maintenance costs, or building plants with more resilient (and expensive) materials.

Direct Air Capture

Direct air capture is another possibility, using chemical filters to grab CO2 from the air itself. While this means that carbon capture no longer needs polluting exhaust flowing through it, it is extremely expensive right now, costing around $US600-800 to process a tonne of carbon dioxide. Given that this process would need to remove billions of tonnes of CO_2 to reverse the effects of climate change, prices will need to go down for this to be practical.

These are also very energy-intensive. Running enough direct air capture machines to stop the worst effects of climate change would likely use up half of the world's current energy production.

The effectiveness of CCS also depends in large part on the economic incentives for industries to use the technology. In particular, government investment in these projects is often vital to cover their construction and operating costs. Measures such as carbon taxes, emission trading schemes and other economic benefits contribute towards greater uptakes of CCS technology. For instance, Norway's state-owned oil company Statoil credits the introduction of carbon taxes towards increased investment in CCS technology. These incentives, however, often must remain throughout a project's planning stages and operating life, or they may be abandoned.

So is capturing carbon the answer to global warming?

CCS technology opens up many potential opportunities for carbon capture. While there are few plants right now, companies plan on expanding this, especially in new locations such as the Middle East and China.
On the one hand, some believe it can play a vital role in stopping global temperatures from rising. On the other hand, many of these projects prop up fossil fuel industries.

A mix of approaches will be valuable in stopping climate change. For CCS plants to succeed in keeping temperatures rising over 2 degrees (above pre-industrial levels), they will need to extract around 5 billion tons of CO_2 from the atmosphere every year. It is important to note that the world's largest CCS plant can only process about 4000 tons of carbon dioxide a year, at a rate of $US600-800 per tonne. However, this is minuscule compared to the 35 billion tonnes created from fossil fuels alone**.**

For this technology to be cheap enough to use, we would need many more CCS plants. In contrast, renewable energy is expanding dramatically, often making it cheaper than fossil fuels. This can divert funding away from renewable technology, to let fossil fuel industries keep polluting.

Even if CCS technologies turn out to be useful, we need other solutions to preserve our climate. Capture-based solutions run the risk of CO2 leaking and polluting our air regardless.

So, how do we solve global warming?

As a consumer, your voice is vital to the clean energy debate. There are many potential ways we can deal with climate change. However, we must seek out information to find relevant, science-based solutions.

We at the THRIVE Project have a framework that aims to do this. It uses scientific data to allow anyone from governments to individuals to track their impacts, and know what actions will have the least impact on our precious Earth. Together, we can make sure everyone has the chance to not just survive, but thrive!

If you want to plant the seeds of change, click here to plant trees for life or find out more about our THRIVE platform.

Otherwise, we regularly post articles like this one on our THRIVE Blog page.