Direct Air Capture

A SENIORS FOR CLIMATE ACTION NOW! BRIEFING

What if instead of reducing our carbon emissions, we could just pull carbon dioxide out of the air and bury it underground? The fossil fuel industry would have us believe that it's really that simple. Unfortunately, it's not.

Carbon dioxide is a natural constituent of the Earth's atmosphere, but over the last century its concentration has increased by more than a third. There is strong evidence that CO_2 is the single most important greenhouse gas; it is considered to be the 'control knob' governing the Earth's temperature and therefore its climate.[1]

International efforts to mitigate the effects of increasing global temperatures have therefore focused primarily on reducing emissions of CO_2, and the other strong greenhouse gases: methane and nitrous oxide. The goal is to arrive at a condition of 'net zero emissions' by the middle of the century, as set out in the Paris Agreement of 2015: an agreement to which Canada, along with over 190 other countries, is a party.[2]

When this 'net' condition is eventually reached, it is virtually certain that global temperatures be at least 2°C higher than pre-industrial levels. The more ambitious target of keeping temperatures below 1.5°C, was always going to be a huge challenge: and one that in retrospect the industrial countries never seriously considered meeting.

> "CO_2 is the Earth's climate 'control knob'

Scientists have run multiple models of current energy and climate policies that aim to reduce GHG emissions over the period through to 2050. The models generally show that substantially reducing emissions to net zero is not sufficient to keep the Earth's temperatures rise below 2°C. This result has led scientists to conclude that technologies must be developed that remove carbon dioxide directly from the atmosphere. Trees and other bio-mass do this naturally; but slowly and not permanently.

CO_2 Removal (CDR)

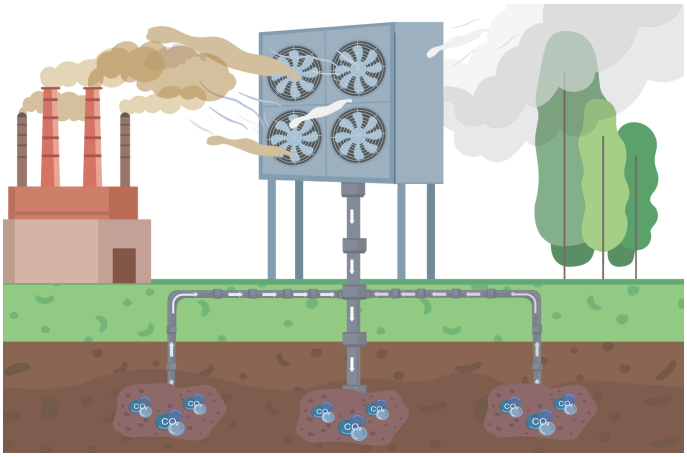
There are several possible ways to remove carbon dioxide from the air. Broadly speaking they can be classified as nature-based or technology-based. They are outlined in the table below.[3]

Nature-based CDR
• Wetland and peatland • Cropland, grassland and agroforestry • Reforestration and afforestration • Blue carbon management
Technology-based CDR
• Direct Air • Bioenergy with carbon capture and storage • Biochar and bio-oil • Enhanced Weathering • Ocean alkalinity enhancement • Direct ocean capture

The nature-based technologies are well understood and generally less costly, but their capacity to sequester carbon for long periods of time is less assured—especially as many forests have now become a source rather than a sink for carbon as higher temperatures and drought make them vulnerable to fire. Among the technology-based CDRs, bioenergy carbon capture and storage, generally known as BECCS, has been deployed in several countries and at significant scale. However, the claim that it results in a net reduction in emissions has been strongly challenged.[4] It is the subject of a separate SCAN! briefing. In this note, we will focus on Direct Air Capture.

The DAC Technology

Two of the largest companies involved in direct air capture are Climeworks (Swiss) and Carbon Engineering (Canadian). Both technologies operate on a similar concept: blowing very large quantities



of air through a filter that absorbs the carbon dioxide. The absorbent, which may be either solid or liquid, is then heated to release the CO_2 which is removed and contained. The gas must then be conveyed through a pipeline to a site where it is pumped underground for permanent storage. This last step is exactly the same as the carbon capture and storage (CCS) process described in the SCAN! Briefing on this topic.

The challenge with Direct Air Capture is that the concentration of carbon dioxide in air is extremely low. It is generally reported as part per million (ppm) but perhaps more easily understood as a percentage. 425 ppm of CO_2 is equal to a concentration of just 0.0425 percent.

> **Removing one tonne of CO_2 requires the equivalent volume of about 760 Olympic sized pools of air**

Given this low concentration, removing just one tonne of CO_2 from the atmosphere requires processing about 1.9 million cubic meters of air, which is roughly equivalent to the volume of about 760 Olympic-sized swimming pools. All that air must be moved across a CO_2-capturing sorbent — a process requiring lots of large equipment. For example, one recently proposed design for capturing 1 million tonnes of CO_2 per year would require an "air contactor" equivalent in size to a structure about three stories high and five kilometres long.[5] That is just for 1 million tonnes a year of CO_2 removed. According to most models, the minimum scale of a viable CDR technology should be capable of removing CO_2 at a rate of at least 1 billion tonnes a year. One thousand times greater.

Apart from these gargantuan dimensions, the amount of energy required to blow enormous volumes of air through a chemical absorbent is extremely high. The numbers generally reported for removing a tonne of CO_2 from the air are in the range of 2000 kWh of energy of which about 20 percent is electricity.[6] An installation removing 1 billion tonnes of CO_2 a year would therefore consume about 400 TWh of electricity—**roughly two-thirds of the total electricity demand of all Canada in 2025.**

This power generation must obviously be of free of carbon. The industry proposes that the electricity for Direct Air Capture could be generated from methane with the carbon dioxide being captured and stored. Given the inherent limitations of carbon capture and storage–as documented in SCAN!'s Briefing on the subject, this concept is unlikely to result in a significant reduction in atmospheric concentrations of CO_2 when the emissions and leaks from gas processing, electricity generation, CO_2 pipelines, and seepage from geologic storage are all taken into account.

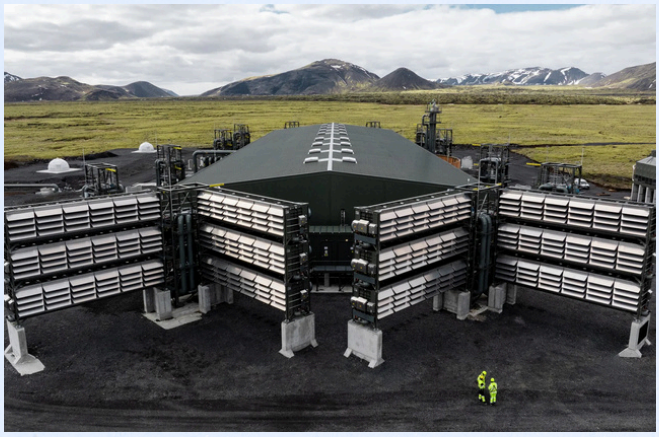


IMAGE SOURCE:CLIMEWORKS

The Mammoth plant in Iceland designed and operated by Climeworks is intended to capture 36,000 tonnes of CO_2 a year. It commenced operations in 2024.

The performance of the prototype installations operating in Iceland are not encouraging. Climework's first attempt, called Orca, never reached its modest design capacity of 4,000 tonnes of CO_2 a year: capturing only about half that amount. The larger Mammoth installation, rated at 36,000 tCO2/yr has reportedly managed to capture only 105 tonnes of CO_2 after 10 months of operation.[7] According to Climeworks, Mammoth requires 5-6 MWh of electricity per tonne of CO_2 captured. To offset Iceland's total emissions of 12.4 $MtCO_2$ in 2024, about 72 TWh of electricity would be needed—four times the country's annual electricity production.[8]

The Carbon Gravy Train

It's been described as the new Gold Rush: "It's the single greatest opportunity I've seen in 20 years of doing venture capital", enthused Damien Steel, the chief executive of Canada-based Deep Sky. "The tailwinds behind the industry are greater than most industries I've ever looked at."[9] He's not wrong. The consulting firm McKinsey looked into its crystal ball and liked what it saw. A CDR industry capable of delivering gigaton-scale removals could be worth up to $1.2 trillion by 2050. That's trillion.[10]

How does a technology that has almost no realistic chance of being deployed at anything above small-scale operations due to its inherent energetic and geophysical limitations attract such a huge amount of venture capital? The answer is that thousands of ordinary people who are concerned about climate change have taken steps to reduce their carbon footprint, many purchasing carbon credits from companies that promise to capture carbon from the sky. And lots of people put their money into Climeworks: a company that was recently ranked second on Time Magazine's list of the 100 top green tech companies in the world.[11]

According to one report, Climeworks has 21,000 subscribers—people who individually pay the company to offset their personal emissions of perhaps a tonne of CO_2 or more a year; each credit costing around $1,000 CAD. One third of all the credits that Mammoth is designed to capture over the next 25 years have already been sold.[12]

The DAC-fuelled trajectory of Deep Sky is a case in point. The Montreal-based company is building two Direct Air Capture installations in Canada. Billing itself as the "world's first cross-technology carbon removal project developer", the company has attracted a slew of high-profile investors: Microsoft, Royal Bank of Canada, Bank of Montreal, Breakthrough Energy Catalyst (Bill Gates' group), and Investissement Quebec. "Quality, affordability, certainty, scalability, and tech diversity" are the benefits touted by the company to its investors.[13]

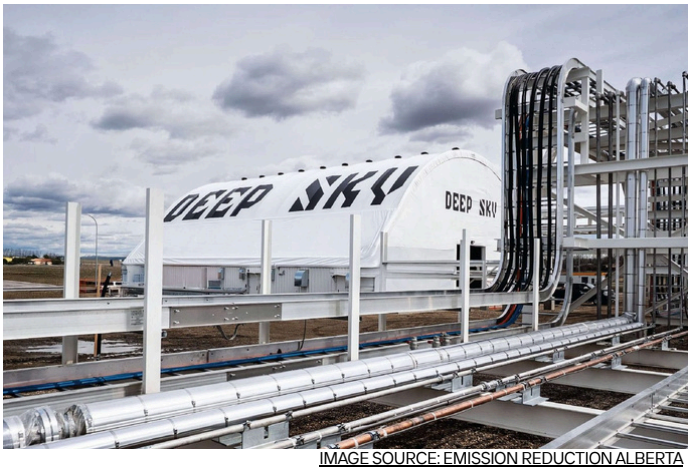


IMAGE SOURCE: EMISSION REDUCTION ALBERTA

Deep Sky DAC innovation centre, Innisfail, Alberta.

In Innisfail, Alberta, Deep Sky Alpha claims to be the world's first "innovation and commercialization centre for carbon removal technology". The centre will test "multiple direct air capture technologies

side by side under real-world Canadian conditions."[14] Eight Canadian DAC start-ups are slated to test their technologies in 2025.[15] The amount of carbon the centre will actually capture is tiny: only 3000 tonnes of CO_2 a year, but that hasn't stopped investors from piling in to get a piece of the action. And notably absent from the promotional material is any indication of what Deep Sky does with the captured carbon.

Farther to the east, Deep Sky is building Deep Sky Manitoba. This is a huge 1-billion-dollar installation designed to capture 500,000 tonnes of CO2 a year, which would put it in the same league as the Stratos plant under construction in Texas. The Canadian government is enthusiastic and has reportedly given Deep Sky a "central role in its carbon management strategy, which aims to reduce the country's GHG emissions by 40-45 per cent below 2005 levels by 2030."[16] Clearly, Deep Sky has persuaded investors with deep pockets not to miss out on the 'gold rush'. "Join the forefront of investors driving the future of carbon removal", the website implores.

But not everyone is convinced. Stanford's Mark Jacobson, professor of environmental science, doesn't mince words: "Direct capture is a scam, carbon capture is a scam,... These are all scam technologies that do nothing for the climate or air pollution."[17] Direct Air Capture is a gimmick of the fossil industry to keep operating & pretend they are doing something useful, when they are only increasing CO_2, air pollution, fossil mining & fossil infrastructure.[18]

> **Direct Air Capture is a gimmick of the fossil fuel industry to... pretend they are doing something useful, when they are only increasing CO_2 air pollution.**

The Drawdown Project's new website, Drawdown Explorer, is equally adamant, stating: "Based on the difficulty of capturing low concentrations of CO_2 from air and the associated technological, energy consumption, and financial challenges facing DAC, it is unlikely that this climate technology can be scaled up to remove globally meaningful amounts of CO_2.[19]

IMAGE SOURCE: 1POINTFIVE

The Stratos plant designed by Carbon Engineering under construction in Texas in 2025. It is designed to capture 500,000 tonnes of CO2 a year and to permanently dispose of the gas in underground storage.

> **The cheapest and most effective way of removing a tonne of carbon dioxide from the air is not to put it there in the first place.**

Direct Air Capture is a scam of monumental proportions. The tragedy is not just that lots of ordinary folk trying to reduce their carbon footprint are being duped into wasting their money, huge amounts of government funding and private capital are being invested in a technology that will never make any real difference. The opportunity costs are enormous. If these millions of dollars had been invested in renewable sources of energy displacing fossil fuels the reduction in global carbon emissions would have been substantial. The Canadian government should not commit any more funds or subsidies for Direct Air Capture and should disassociate itself completely from the commercial operations of Deep Sky. And we might remind the government of one final point: the cheapest and most effective way of removing a tonne of carbon dioxide from the air is not to put it there in the first place.

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