

New carbon dioxide capture technology is not the magic bullet against climate change

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Credit: AI-generated image ([disclaimer](#))

According to a recent major UN report, if we are to limit temperature rise to 1.5 °C and prevent the most catastrophic effects of climate change, we need to reduce global CO₂ emissions to net zero by 2050. This means eliminating fossil fuel use fast – but to cushion that transition and offset the areas in which there is currently no replacement

for combustibles, we need to actively remove CO₂ from the atmosphere. Planting trees and rewilding are a large part of this solution, but we are highly likely to need further technological assistance if we are to prevent climate breakdown.

So when recent news emerged that Canadian company Carbon Engineering has harnessed some well-known chemistry to capture CO₂ from the atmosphere at a cost of less than \$100 a tonne, many media sources hailed the milestone as a [magic bullet](#). Unfortunately, the big picture isn't as simple. Truly tipping the balance from [carbon source](#) to [carbon sink](#) is a delicate business, and our view is that the energy costs involved and likely downstream uses of captured CO₂ mean that Carbon Engineering's "bullet" is anything but magic.

Given that CO₂ only accounts for 0.04% of the molecules in our air, capturing it might seem like a technological marvel. But chemists have been doing it on small scales since the 18th century, and it can even be done – albeit inefficiently – with supplies from the local hardware store.

As secondary school chemistry students will know, CO₂ reacts with limewater (calcium hydroxide solution) to give milky-white insoluble calcium carbonate. Other hydroxides capture CO₂ in the same way. Lithium hydroxide was the basis of the [CO₂ absorbers](#) that kept the astronauts on Apollo 13 alive, and potassium hydroxide captures CO₂ so efficiently that it can be used to measure the carbon content of a combusted substance. The 19th-century apparatus used in this latter procedure still features on the American Chemical Society's logo.

Unfortunately, this isn't a small-scale problem anymore – we now need to capture billions of tonnes of CO₂, and fast.



Credit: Marcin Jozwiak from Pexels

Carbon Engineering's technique is hydroxide chemistry at its best. At its [pilot plant](#) in British Columbia, air is pulled in by large fans and exposed to potassium hydroxide, with which CO_2 reacts to form soluble potassium carbonate. This solution is then combined with calcium hydroxide, producing solid and easily separable calcium carbonate, along with potassium hydroxide solution, which can be reused.

This part of the process costs relatively little energy and its product is essentially limestone – but making mountains of calcium carbonate doesn't solve our problem. Though calcium carbonate has uses in agriculture and construction, this process would be far too expensive as a

commercial source. It also isn't a practical option for government-funded carbon storage due to the massive quantities of calcium hydroxide that would be required. To be feasible, direct air capture needs to produce concentrated CO₂ as its product, which can either be safely stored or put to use.

Thus, the solid calcium carbonate is heated to 900 °C to recover pure CO₂. This last step requires a vast amount of energy. In Carbon Engineering's natural gas-fired plant, the whole cycle generates half a tonne of CO₂ for every tonne captured from air. The plant does capture this extra CO₂, and of course could be powered by renewable energy for a healthier carbon balance – but the problem of what to do with all the captured gas remains.

Swiss start-up company Climeworks is using similarly captured CO₂ to [aid photosynthesis](#) and improve crop yield in nearby greenhouses, but as yet the price is nowhere near competitive. CO₂ can be sourced elsewhere for as little as one-tenth of Carbon Engineering's \$100 bottom line. There are also much cheaper ways for governments to offset emissions: it is far easier to capture CO₂ at the emission source, where the concentration is much higher. So this technology is likely to mainly interest high-emitting industries which may stand to benefit from CO₂ with green credentials.

For example, one of the key investors in Carbon Engineering's capture technology is Occidental Petroleum, a major user of [Enhanced Oil Recovery](#) methods. In one such method, CO₂ is pumped into oil wells to increase the amount of crude oil that can be recovered, thanks to increased well pressure and/or improving the flow characteristics of the oil itself. However, including the energy cost of transporting and refining this extra oil, using the technology in this way will likely increase net emissions, not decrease them.

Another key spoke of Carbon Engineering's operations is its [Air To Fuels](#) technology, in which CO₂ is converted into combustible liquid fuel, ready to be burned again. Theoretically this provides a carbon-neutral fuel cycle, provided that each step of the process is powered with renewable energy. However, even this use is still a far cry from a negative emissions technology.

There are promising alternatives on the horizon. Metal-organic frameworks are sponge-like solids that squeeze the equivalent CO₂ surface area of a football pitch into the size of a sugar cube. Using these surfaces for CO₂ capture requires far less energy – and companies have started exploring their commercial potential. However, large-scale production has not been perfected, and questions over their long-term stability for sustained CO₂ capture projects mean that their high cost is not yet merited.

With little chance that technologies still in the laboratory will be ready for gigatonne-scale capture within the next decade, the methods employed by Carbon Engineering and Climeworks are the best we currently have. But it's important to remember that they're nowhere near perfect. We will need to switch to more efficient methods of CO₂ capture as soon as we are able. As Carbon Engineering's founder David Keith himself [points out](#), carbon removal technologies are overhyped by policymakers, and have received "extraordinarily little" research funding thus far.

More generally, we must resist the temptation to see direct air capture as a magic bullet that saves us from having to address our carbon addiction. Reducing or neutralising the carbon burden in the life cycle of hydrocarbon fuels may be a step towards negative emissions technologies. But it is just that – a step. After being on the wrong side of the [carbon](#) ledger for so long, it's past time to look beyond just breaking even.

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