# WASHING CARBON OUT OF THE AIR

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The world cannot afford to dump more car-box into the atmosphere. Yes it is cutting back. All indications are that the concentration of $CO_2$ will continue to rise for decades. Despite great support for renewable energy, developed and developing countries will probably burn more oil, coal and natural gas in the future.

So how are we to keep the $CO_2$ concentration from rising beyond its current level of 389 parts per million? Unless we ban carbon-based fuels, one option is to pull CO2 out of the air. Allowing forests to expand in area could absorb some of gas, but humans produce so much that we simply do not have the land available to sequester enough of it. Fortunately, filtering machines – think of them as synthetic trees – can capture far more $CO_2$ than natural trees of a similar size.

Carbon dioxide would have to be captured on a grand scale of curtail climate change, but the basic concept is already well established. For decades scrubbers have removed $CO_2$ from the air breathed inside submarines and spaceships and from air used to produce liquid nitrogen. Various chemical processes can accomplish this scrubbing, but machines with solid sorbents promise to trap the most gas per unit of energy required. Early, small prototype units suggest that wide dissemination of solid-sorbent machines could stop or even reverse the rise of atmospheric $CO_2$.

Like their leafy counterparts, air capture machines come in different shapes and sizes. Demonstration units intended to go beyond the laboratory prototypes should each trap from a ton to hundreds of tons of $CO_2$ per day. Their design being developed by Columbia and Global Research Technologies offers an example of how the technology can work. Thin fibers of sorbent material are arranged into large, flat panels akin to furnace filters, one meter wide and 2.5 meters high. The upright filter panels will revolve around a circular, horizontal track that is mounted on top of a standard 40-foot (12.2 meters) shipping container. The panels will be exposed to the air. Once they are loaded with $CO_2$, they will move off the track and down into a regeneration chamber inside the container. There the trapped gas will be freed from the sorbent and compressed to a liquid. The refreshed panel will be moved back up onto the track to pull more gas from the wind.

Many industries use carbon dioxide - to carbonate beverages, freeze chicken wings and make dry ice. The gas is also used for stimulating the growth of indoor crops and as a nonpolluting solvent or refrigerant. Few industrial sources exist, so the price is driven by the cost of shipping.

With the advent of clean energy sources, however, the prize for air capture would be the production of fresh liquid fuel from $CO_2$ feedstock. As noted earlier, well established technologies such as electrolysis and reverse water-gas shift reactions can produce synthesis gas from $CO_2$ and water, leading to fuel synthesis. The big cost is the electricity needed.

Until fuel synthesis becomes affordable, humankind will have to dispose of all the emissions it generates. Technologies such as geologic sequestration and mineral sequestration are being developed for storing $CO_2$ collected at power plants. Air capture can work with the same storage approaches, and machines could be installed at the same disposal sites.

Until clean transportation technologies become significantly more efficient, extracting carbon from the air would allow cars, planes and ships to continue burning liquid fuels, with their emissions captured by far away air collectors. Unlike ozone or sulfur dioxide, $CO_2$ remains in the atmosphere for decades to centuries, giving it ample time to travel extensively. An equivalent amount of the gas could even be removed before emissions are released; a car could be made carbon - neutral by collecting its estimated lifetime emission of 100 tons before the vehicle rolls off the assembly line.

Air capture could also be a cheaper way to sequester emissions from power plants, especially older ones not easily retrofitted with flue stack scrubbers or those located far from storage sites. And in a future world in which atmospheric $CO_2$ concentrations have already been stabilized, air capture could even drive levels down. In effect, air capture can deal with past emissions.