



# Cutting climate pollution isn't enough – we also need carbon removal

By Fred Krupp and Ernest J. Moniz

It has been almost four years since the Paris climate agreement was signed. But as leaders gather in New York this week for the United Nations Climate Change Summit, the world remains far off track from meeting the Paris objective of limiting global warming to well below 2 degrees Celsius – and pursuing efforts at 1.5 degrees.

The consequences of falling short are enormous. This year, the U.S. government's fourth National Climate Assessment documented the huge economic and social impacts of unchecked warming. The Pentagon has repeatedly warned of the impacts on national security and our troops.

Achieving a 100 percent clean economy will require a swift transition to renewables and other zero-carbon energy sources. But we also need to face the reality that meeting the Paris target will require taking carbon out of the atmosphere at massive scale. In part, that's because eliminating emissions will be very challenging for some sectors, especially the transportation industry and agriculture. Removing carbon from the atmosphere would also bring concentrations down, helping to stabilize the climate at safer levels. So, the push for clean energy must be supplemented by a suite of technologies known as carbon dioxide removal (CDR).

It is not a question of what we'd prefer. It's a question of insurmountable math.

The crucial role carbon removal must play is

becoming more widely recognized. The 2018 Intergovernmental Panel on Climate Change report stressed the importance of carbon removal, and the U.S. National Academies of Sciences, Engineering and Medicine late last year estimated that ten billion tons of CO<sub>2</sub> will need to be pulled from the atmosphere annually by 2050, and double that by 2100. For context, today's global emissions are less than 40 billion tons per year. If the 10 billion tons of CO<sub>2</sub> from CDR were stored underground, that would be roughly double the world's annual oil production.

The good news is that there are a surprisingly large number of promising pathways for carbon dioxide removal. Nature-based approaches include reforestation and forest management as well as agricultural practices that increase carbon stored in soils. Some of the attendant challenges include competition for land and permanence of the carbon sequestration.

Technological approaches include direct air capture – machines that actually suck carbon from the air – and technologically-enhanced natural processes, such as plants genetically modified with deep roots to fix carbon in the soil; enhanced mineralization, which uses certain reactive rocks to bind with carbon from the air; and accelerated ocean uptake in phytoplankton. These technologies are immature and require considerable research, development and demonstration to ensure viability and



affordability at very large scale.

Despite the urgency, there is no dedicated federal effort to develop these crucial technologies; existing programs are piecemeal and largely focused on sequestering emissions from industrial and electricity generating sources.

The National Academies recommended the rapid establishment of a robust, focused, scalable and accelerated federal research program spanning the Departments of Energy and Agriculture, the National Oceanic and Atmospheric Administration and the National Science Foundation, among others. Such a program would encompass the full range of technological pathways that can remove CO<sub>2</sub> from the environment. "Clearing the Air," an analysis of CDR's value and a proposed plan to deploy it, has been completed by the Energy Futures Initiative. Over the next decade, the program scale would be about a billion dollars a year.

Carbon dioxide removal is not a magic bullet. We must do everything we can to deploy innovative low- and zero-carbon methods to generate electricity, heat homes, fuel vehicles, and power industry, creating new economic opportunities in the process. Tackling the climate crisis also requires placing a declining limit and a price on carbon pollution, as well as a significant increase in energy technology innovation and deployment across the board.

But CDR is also not a "Plan B." It is a critical part of any "Plan A" for climate, a necessary complement to emission reduction. It can provide more flexibility and optionality in policy planning, which could ease the transition to a carbon-neutral economy while minimizing transition costs and providing greater assurance that science-based climate

goals can be met in a timely manner. It would eventually enable a net negative global economy that could bring the atmospheric carbon concentrations down — and global temperatures with it.

We have delayed meaningful action for far too long. As a result, the scale and urgency of the challenge is such that we cannot simply work on doing better in the future. We need to correct what we did in the past. Carbon removal is the enabler.

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