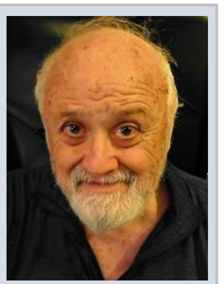
Climate *Cool-down*

HOW TO TREAT CLIMATE DISEASE

"We must use CO_2 scrubbers to clean up the air and reverse the acidification in the ocean. We must plan to finish the job twenty years from now—**not start, but finish**."



William H. Calvin, Ph.D.
wcalvin@uw.edu
UNIVERSITY of WASHINGTON

We have driven ourselves into climate's danger zone for major destruction. It's time to get out of here, to stop and back up. We now need, not long-term improvements, but emergency repairs to survive the short run. But *how*?

Getting our act together in time

Doubling down on emissions reduction will buy us little. Making some more clouds cannot be done uniformly and so rearranges the winds. Smoke-stack capture is expensive nonsense when you look carefully. Most of the other options—even ones that sound good for the long term— fail the Big Enough, Quick Enough, or Sure-fire require-ments. The window of opportunity to accomplish something effective is until about 2040, so forget about those end-of-the-century numbers.

What's left? We must use CO_2 scrubbers to clean up the air and reverse the acidification in the ocean. We must plan to finish the job twenty years from now—**not start, but finish**.

It's not that I expect civilization to collapse by 2040, but that international cooperation might be lost before then in a series of wars over food resources, leaving us unable to get our act together in time for a much larger cleanup task than if doing it now.

Deploying half of the necessary scrubbers should serve to counter continuing fossil CO_2 production; even if developed countries wean themselves off fossil fuels in one product replacement cycle—say twenty years—many developing countries will desperately burn their local fossil fuels to generate electricity to cool themselves.

In our own interests, we must continuously remove that new fossil CO_2 from the air, along with that from forest fires. Only with the deploy-ment of even more scrubbers will the drawdown of the excess CO_2 begin, finally starting to cool down the air after those preparatory years of scrubbing to counter the continuing emissions.

I have not padded this estimate to allow for contingencies. We will need to build in a consid-erable safety factor, both in scrubbing capacity and in speed of deployment. That eliminates most of the candidates you might have heard about. The chemical CO_2 scrubbers used on submarines also fail the Big Enough and Quick Enough tests.

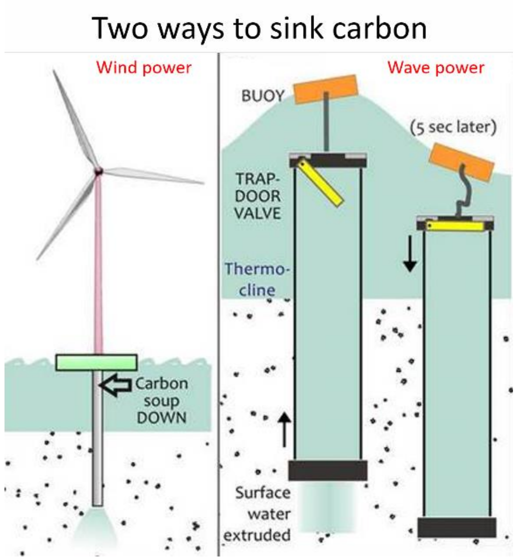
Sinking the excess CO_2 into the ocean depths

Photosynthesis takes CO_2 out of the air to make plankton but when they die, 98 percent of that new organic carbon becomes CO_2 again via bacterial respiration, mostly within a week or two, and so right back into the air. Less than 1 percent of the carbon falls to the sea floor as little shells to make more limestone.

One strategy is to sink the live plankton into the ocean depths within that week-long period, depriving the surface bacteria of their food and so delaying the return of CO_2 to the air until the deep water upwells, spread out over six thousand years. This takes care of the acidification problem at the same time.

To augment this with a plankton bloom, it doesn't take iron filings. One can pump up nutrients from where they accumulate just below the thermo-cline (on those flooded coastal plains known as the Continental Shelf, that's about 50 meters down). Though that also brings up some undesir-ed CO_2 (leading some to prematurely dismiss ocean fertilization as a candidate), what CO_2 comes up is easily countered by the amount of CO_2 production one delays by pumping surface waters down into the depths. You must pair your pumps, both pushing and pulling. That also avoids the creation of a fish-killing anoxic zone from fertilization-only.

Once the cleanup is complete and zero annual emissions are maintained, a few pairs can be turned on and off like an air conditioner to regulate global temperature. But a large number should be maintained as a reserve.



Advantages of plankton plantations

Push-pull pumping for fertilization and sinking has some unique advantages compared to other CO_2 removal proposals. It is **big, quick, and sufficiently sure-fire**. It is relatively low-tech. It does not compete for land, fresh water, fuel, or electricity. It does not hinge on improbable actions by developing countries. It is impervious to drought and to holdout governments trying to bargain for more mitigation money. Because **it merely augments natural up- and down-welling ocean processes,** many of the side effects are already known.

My push-pull pumping principle sounds simple, but it (or something similar) needs immediate work by real experts who can anticipate, and work around, side effects. What emerges from their work may owe little to my ocean pipes example of the underlying principle.

Backing out of the Danger Zone

Most of our climate problems could be repaired by cleaning up the excess CO_2 in the air and so cooling things off. However, because of extreme weather, the cleanup must be big, quick, and secure. Doubling all forests might satisfy the first two but it would be quite insecure—currently even rain forests are burning and rotting, releasing additional CO_2.

However, our escape route is not yet closed off. We can still do the equivalent of plowing under a cover crop, using perhaps one percent of the ocean surface for the next twenty years. A sustained bloom of algae is fertilized by pumping up seawater from the depths—whereupon another wind-driven pump flushes the surface water back into even deeper depths before its new biomass becomes CO_2 again. When the sunken biomass does decompose, the return of the CO_2 to the atmosphere is smeared out over 6,000 years. Such a slow return of excess CO_2 can be countered by forestry practices.

Putting current and past emissions back into secure storage would lower the global overheating. The plankton plantations could then be kept in readiness for cooling the planet in a methane emergency.

So let us consider floating windmills (or equivalent wave-powered pumps, powered by the wind at one remove). They could pump up the nutrients that accumulate in the ocean depths. A second set of pumps could carry the enriched carbon soup down into the thousand-year depths.

Those dissolved feces and such contain hundreds of times more organic carbon than does the living biomass—which is what makes downwelling surface water such a big deal compared to merely settling out the larger debris and fecal pellets.

In my preliminary estimates based on algal growth rates in algaculture (see the **4th** handout), the plankton plantations would need to cover about 0.8% of the ocean surface, an area equal to that of the Caribbean. The push-pull pumps would likely be scattered around the outer continental shelves in prime fishing grounds belonging to well-developed countries that can afford it. Since the fish and fishermen will love a plankton plantation, there is a cognitive carrot: a yearly payoff in fish catch while growing the climate fix with its payoffs for everyone.

Just as farmers grow a nitrogen-fixing crop of legumes and then plow it under, we would be growing a carbon-fixing crop of plankton and then pumping it under. Push-pull pumping looks to be big, quick, and secure. It illustrates that there is still at least one escape route open to us that might cool things down, reverse ocean acidification, and reverse the part of sea level rise that is due to the thermal expansion of the oceans.

From concept to proof of principle, to demonstration project and then deployment often takes more than a decade—though with wartime priorities, World War II history shows that several years may suffice when multiple solutions are pursued simultaneously.

Series home: Print, and find additional handouts at, *WilliamCalvin.org/climate*

Reading: *The Great CO_2 Cleanup*, WilliamCalvin.org

C. H. Greene et al. *Earth's Future,* via doi.org/10.1002/2016EF000486

2018-06-14